Training Novices on Hierarchical Task Analysis

Sarah Felipe

Georgia Institute of Technology

Abstract

The training of a complex task such as task analysis is an area that very few have explored. This study examines how different training methods affect knowledge acquisition, focusing on content learned and errors made by novices in the initial phase of learning of Hierarchical Task Analysis (HTA). Three types of declarative instructions were compared: procedures, decision/actions, and concept map, which were representative of different types of diagrams (matrix, network, hierarchy). Participants were assigned to one of the training conditions and instructed to perform task analyses of five different tasks (making a piece of toast, making a cup of coffee, painting a door, making a phone call, and making Vetkoek - a South African main course). Questionnaire data (declarative knowledge) and task analyses (procedural knowledge) were coded on five criteria: hierarchical representation, stating high-level goal, stating plan, stating subgoals, and satisfaction criteria. Results indicated that participants identified some criteria (goals, subgoals) more often than others as being representative of HTA (hierarchical representation). Furthermore, the nature of the task had a greater effect on the knowledge acquired about HTA than the differences in training material at this early stage of learning. During initial training of HTA it is important that more detailed instruction materials be distributed to allow for greater understanding of HTA. This study informs research about various types of diagrams and also adds to the literature on training HTA.

Keywords: training, hierarchical task analysis, HTA, visual representations

Training of Novices on Hierarchical Task Analysis

Task analysis is a broad term that encompasses a wide variety of methods and techniques for analyzing a task. Task analysis is applicable in numerous settings and can be found in a variety of psychological domains. The various task analysis methodologies can be applied to areas such as staffing and job organization, training, person specification, allocation of function, and are most commonly found in the applied fields of human factors and industrial/organizational psychology (Kirwan & Ainsworth, 1992). For this study we were interested in how task analysis can be used in training, and more specifically in training human-task or computer interaction (McGrew 1997; Shepherd, 2000). The application of task analysis to training has become invaluable to the work place; however due to the sheer number of varying methods of task analysis it has become very difficult to train task analysis itself (Patrick, Gregov, & Halliday, 2000). A variety of cognitive processes are involved in the performance of a task analysis and the components of the processes must be understood to train task analysis.

ACT-R

Human cognitive processing is complex, which has lead to the creation of numerous cognitive theories to understand and explain the complexity of cognition. For the purposes of this study, we will use the Adaptive Character of Thought theory, or ACT-R theory devised by Anderson (1996), as a representative model for cognition. The ACT-R theory explains that cognitive processing can be described as the interaction between procedural and declarative knowledge where procedural knowledge is defined as a set of production rules, and declarative knowledge is represented through schemas of units called chunks. Anderson defined these units as the products of encoding processes of objects or transformations in the environment that were responsible for human cognition. The production rules and chunks are the primary components involved in working memory and incorporated into decision making.

In congruence with the ACT-R theory, task analysis has been devised as a framework, tool, or model to better understand human behaviors and cognition (Shepherd, 1998). The process of task analysis involves extensive decision making and complex cognition that utilizes both the declarative knowledge and procedural knowledge bases described by Anderson's ACT-R theory.

Task Analysis and Hierarchical Task Analysis

The topic of task analysis in and of itself is complex as there is no one clear cut definition. Scientists have established that task analysis operates as a framework to carry out some sort of "goal" or "task" but they are unclear as to what the framework specifically applies to (Shepherd, 1998). The goal of a task analysis is to serve as a model to illustrate, analyze, and predict the human-task interaction (McGrew, 1997). For this study we defined task analysis as a flexible framework that can be used to represent the goals achieved through human-task interaction (McGrew, 1997; Shepherd, 1998).

As stated previously, there are numerous forms of task analyses. One specific version of task analysis is called Hierarchical Task Analysis, or HTA. This form of task analysis was first introduced through the work of Annett and Duncan (1967) as a need to address greater cognitive understanding of a wide range of tasks (Annett, 2004). HTA examines tasks by exploring the hierarchy of goals and establishing plans of a person to determine when and how the subordinate goals should be achieved (Shepherd, 1996).

There are three governing principles of HTA established by Annett, Duncan, Stammers, and Gray (1971): the first principle is that at the highest level of HTA, a task is renamed an operation and that operation is defined by its goals that carry out the operation's objective. Second, the operation can be divided into sub operations or subgoals that are measured by task performance. The third and final principle of HTA is that the relationship between the goals and subgoals is inclusive and hierarchical. The unique quality of HTA stems from the three underlying principles that make up HTA. In addition to the hierarchy of goals that HTA addresses, this version of task analysis provides an order or structure to the analysis. The analysis can have as much or as little detail as necessary for each task, and the actions of the task operator are directly linked to the goals or requirements of the task (Kirwan & Ainsworth, 1992).

Training

HTA is useful in many domains such as instructional development, design, and human-computer interaction; however, it can be difficult to perform (Astley & Stammers, 1987; Patrick, 1992; Patrick et al., 2000; Shepherd, 1993). The difficult nature of HTA was investigated by Patrick and colleagues, who conducted two studies that examined the difficulties of learning HTA and compared various instructional conditions for training participants to conduct HTA. More specifically the first study examined the effects of declarative training on novices and focused on the types of errors that were made by the novice task analysts. The data were analyzed on a set of criteria created by the researchers from some of the main features of HTA and coded for errors based on whether the task analyses matched the criteria set. Some of the errors they found included: poor decomposition of operations, a lack of logical equivalence in the levels, omissions (operations were absent), commissions (extra operations were included), and incorrect boundaries of the analysis.

The second study compared the effects of declarative and procedural training on learning and performing HTA (Patrick et al., 2000). Both studies used similar designs and procedures with the main difference being that the second study introduced two additional types of training. Participants were randomly assigned to one of four training conditions (control, declarative, procedural, or combination), and instructed to perform HTA of one task, making a cup of tea, and then fill out a questionnaire. Patrick and colleagues concluded that the two conditions that included procedural training were better than the declarative and the control condition at producing a qualitatively good HTA.

However, the experimental design of the second study (Patrick et al., 2000) limits the conclusions that can be drawn from the results. For example, the time allotted varied by condition, allowing more time for some training conditions than others. Furthermore, they only measured performance on one task analysis so there is no measure of how the participants learned from the training and transferred knowledge to apply to another task. A transfer task is extremely important in determining if the training is applicable to more than the task being trained, which provides more evidence for the success of training (Goska & Ackerman, 1996). Patrick et al. also provided feedback for some conditions but not for others. Past research has indicated strong evidence that feedback greatly affects training success (e.g., McLaughlin, Rogers, & Fisk, 2008). Overall the two studies conducted by Patrick and colleagues provided a foundation for further HTA studies but left a number of questions unanswered. The goal of the present study was to focus on what novices learn through various procedural training methods which will allow us to better understand how to train a complex task and increase our understanding of HTA.

Training Development

Our experiment used training procedures that specifically address the scenario in which a novice would refer to a book to learn about HTA, where no further guidance or feedback is involved. This is in contrast to where a novice might obtain information through a seminar or workshop in which feedback, examples, and a variety of different media would be available for training.

This experiment consisted of three types of declarative instructions that differed by emphasizing different elements of HTA; procedural steps (procedures), decision-action diagram (decisions), and a concept map (goals). These methods were chosen based on the scenario described previously, that novices will be training themselves using books. These training books include various forms of instructional guidance that novices will be exposed to such as lists of steps, flow charts or path diagrams, or concept maps. The procedural steps were taken and altered from Stanton (2006) and are similar to those presented in the training experiment performed by Patrick and colleagues (2000). We deviated from the Patrick and colleagues study by choosing to use spatial diagrams for our training conditions based on their many advantages including faster access to information, more efficient and memorable representations, and a better overview of the material (Eppler, 2008; Vail, 1999).

There are several classifications of visual representations and we chose to focus specifically on spatial diagrams. Spatial diagrams are a type of abstract diagram that are divided into 3 categories; matrices, networks, and hierarchies (Novick, 2006). Matrices store static information where all elements of information are related in a two-dimensional form (rows and columns). The procedural steps condition is an example of a matrix. The decision-action diagram is an example of a network that can be represented graphically and shows how information is connected in a path-like manner. A concept map is an example of a hierarchy which is a diagram that is organized in levels with all levels attaching to a single node such as the concept map (Novick, 2006).

Concept maps are useful in displaying information and relationships. They are efficient in communicating and facilitating the learning of knowledge to observers with different backgrounds (Eppler, 2008; Vail, 1999). Because this study deals with the training of novices we expect that these concept maps will not only facilitate learning but will be easily interpreted given that they are created for a variety of skill levels and backgrounds.

Additional support for using visual representations comes from a study conducted by Michas and Berry (2000) who studied the effects of various media training conditions on the procedural task of bandaging a wound. The effects were measured on performance of bandaging the wound (reaction time and accuracy) as well as the accuracy of answering questions in a question booklet. The experimenters concluded that training that utilizes both pictures and text is often better than just text or pictures alone. In addition, the results indicated that text instruction alone yielded better training results than training with pictures. However, the results of the Michas and Berry study showed that visual representation training is more effective for declarative tasks (answering a question booklet) than procedural tasks (bandaging a wound). The type of task, declarative or procedural, must also be taken into consideration. Some tasks lend themselves better to visual instruction whereas other tasks lend themselves better to written or textual instruction.

Research has indicated that the effectiveness of training also differs by the complexity of the procedural task (Bhowmick, Khasawneh, Bowling, Gramopadhye, & Melloy, 2007). Bhowmick and colleagues examined the training of numerous multimedia combinations to improve web-based learning of procedural tasks. The authors defined a complex task as incorporating multiple procedures into performing a task. The study found that for a complex procedural task it is best to train people with multiple visual representations of the material to ensure a high rate of learning. This is something to take into consideration with the complexity of HTA, and we may find that a combination of training or instructional methods may improve performance.

Overview of the Study

The purpose of this study was to examine how different types of instructions affect knowledge acquisition and application of HTA. We focused on what content novices learned and what errors they made, by examining various instructional methods and analyzing task analyses conducted by novices. Prior to the experiment, participants were assigned to one of the three training conditions and instructed to use HTA to analyze three “familiar tasks”: making a cup of coffee, making a phone call, and painting a door; as well as one presumably “unknown task”: preparing the dish Vetkoek (a South African main course). To understand what existing knowledge or understanding the participants had of task analysis, there was also an introductory task wherein participants were asked to perform a task analysis of making a piece of toast. This experiment also had a standard time allotment for all training conditions to ensure that all conditions were equivalent. Once the task analyses were collected, participants completed an exit questionnaire that measured familiarity and provided feedback of the experiment. It was hypothesized that the various training conditions would produce task analyses that reflected the emphasis of the training. In addition it was hypothesized that the familiarity of the task would affect the level of decomposition of the task analysis. Finally, this experiment was conducted to establish standard procedures for examining task analyses.

Method

Participants

Participants were 20 younger adults, ranging in age from 18-22 years (*M*= 20.4 years, *SD* = 1.19). All 11 male and 9 female participants had normal or corrected normal vision of 20/40 or better. Two participants were excluded from data analysis because they expressed having had previous experience conducting a HTA or demonstrated proper HTA application on the introductory task before they received any experimental instructions. Participants were recruited through the Georgia Institute of Technology in conjunction with the Experimetrix website. One extra credit per one hour of participation was awarded for a total of two credits upon completion of the experiment. This study took approximately 1.25 hours to complete.

Participants completed a standard set of abilities tests: the Digit Symbol Substitution test that examined perceptual speed (Wechsler, 1997), followed by the Reverse Digit Span which tested participants' working memory span (Wechsler), and finally the Shipley Vocabulary test that examined verbal ability (Shipley, 1940). These tests helped to establish if any differences existed between groups other than the independent variable. A one-way ANOVA was conducted to test the hypothesis that there were no significant differences between the groups in the abilities tests. The experimental groups did not differ significantly on the Digit Symbol Substitution test (F (2, 18) = .96, p = .407), Digital Symbol recall (F (2, 18) = 1.63, p = .229), and Reverse Digit Span (F (2, 18) = 1.2, p =.332). No significant differences between experimental groups were found for the Shipley either (F (2, 18) = .09, p = .911). However the Levene test of Homogeneity showed a violation of the assumption of variance homogeneity. Therefore the three experimental groups do not have equal variance across the abilities tests. The variance statistic of the Digit Symbol Substitution test indicated that the variance for the three groups were equivalent (p = .931). However, the Digit Symbol Recognition (p = .005) and Shipley

Vocabulary (p =.007) tests did not show homogeneity in variance with significant p values. As a result of the lack of homogeneity we must interpret the results with caution because the statistics may be influenced.

Design

The experiment is a one factor design (training condition) with three levels: procedural steps, decision-action diagram, and concept map. The dependent variables included performance and knowledge measures. The declarative knowledge measurement was taken from the first question of the questionnaire that asked participants to state the five main features of HTA. The performance measurement was taken from the task analyses. This experiment incorporated repeated measurement as participants were asked to perform one initial task analysis, three main task analyses, and one final task analysis. To ensure that the order of tasks was equally represented and does not confound the results, the presentation order of the three main tasks to be analyzed was counterbalanced based on a Latin Square (Appendix N). The counterbalancing was also applied to the exit questionnaire in which the task specific questions were presented in the same order as they were in the experiment.

Materials

Introduction to the experiment. To gauge the participant's knowledge and familiarity with task analysis, participants were asked to break down the task of making toast at the outset of the experiment before any instruction was given (Appendix C). The purpose of this task was to understand what task analysis the participants would create before receiving any kind of instruction on task analysis. The task of making toast was chosen to go hand in hand with the example that participants read in their general information on HTA. This exercise also prepared the participants for the task analyses they conducted after they received training.

General information on Hierarchical Task Analysis. Each of the experimental groups read a handout containing general information on HTA (Appendix D), adapted from the introduction of Shepherd (2001, p.1f). This was a general overview of HTA that gave a brief history of HTA, emphasized the hierarchical nature of the analysis, and contained a description of the purpose and goals of HTA. The instructions given to participants deviated from Shepherd's introduction by deletion of the image of the HTA of using a toaster and all references to the image. The image would have given too much information to the participants about the visual presentation format of HTA, and the intent for these instructions was to familiarize participants with general HTA knowledge. In addition some minor modifications were made to the text such as the deletion of the human factors reference made in the first paragraph (it was repetitive) and some small grammatical changes.

Specific instructions on Hierarchical Task Analysis. In addition to the general information on HTA, further instructions were provided to participants depending on the experimental condition they were assigned to. The experimental conditions differed by the emphasis these additional instructions put on certain aspects of HTA. The procedural step condition was a list of steps that highlighted both procedure and plan (Appendix E). These steps were adapted from a framework for conducting HTA emphasized by Stanton (2006). The decision-action diagram condition (Shepherd, 1985) emphasized the decisions and actions involved in conducting a HTA (Appendix F). Finally, the third experimental condition was a concept map that represented the goals accomplished in HTA (Appendix G). This concept map was created from the goals of HTA as stated by Shepherd (2001) and represented an attempt to create a high-level HTA of Hierarchical Task Analysis.

Tasks to be analyzed. For the purposes of this study we defined a task as a problem to be solved or a challenge to be met that included a set of goals, resources, and constraints (Shepherd, 2001). A total of five tasks were used in this study (Appendices H – L). The first task, making a piece of toast, was used as the introductory task that participants analyzed before any instruction was given. Three counterbalanced tasks followed the introductory task. The tasks were chosen because they are commonly performed in the American culture: making a cup of coffee, making a phone call, and painting a door, and thus expected to be part of the general knowledge base. The final task to be analyzed was to prepare the dish Vetkoek (a South African main course), chosen because of its obscureness.

The tasks were chosen to range in familiarity to allow us to examine if there were significant differences between the analyses of an unfamiliar task analysis and a familiar task. To verify that these tasks differed in the participant sample, we performed a repeated measure ANOVA as a manipulation check on the familiarity and frequency ratings that the participants completed in the questionnaire. Participants rated their familiarity of each task by answering the question: "How familiar are you with (Task)?". For each task, participants rated familiarity on a 5 point Likert-type scale (1=not very familiar, 5=very familiar). We also asked the participants about the frequency of performing each task: "How frequently do you (Task)?" and to indicate their answer on a scale from 1 to 5 (1= never, 5=daily).

The results showed that there was a main effect of task for both familiarity ($p < .005$) and frequency ($p < .005$). No significant interactions were found between task and experimental condition (familiarity, $p = .461$; frequency, $p = .807$), nor were there any main effects of experimental condition (familiarity, $p = .833$; frequency, $p = .734$). Therefore we can say that the tasks differed in familiarity and frequency, and this was equally so for the three experimental conditions (see Table 2 for descriptives).

To identify which tasks were more familiar than others we performed paired comparison t-tests. The paired comparisons showed three groups of familiarity. The tasks of making toast and making a phone call were the most familiar. The tasks of making a cup of coffee and painting a door were moderately familiar and the task of making Vetkoek was not familiar (see Figure 1).

The paired comparisons tests on frequency with which the tasks were performed were in unison with the familiarity ratings. The results showed that making a phone call was performed most frequently or daily by the participants, and the tasks of making toast, a cup of coffee, and painting a door were performed at a moderate frequency by participants (around monthly). Finally, making Vetkoek was the least frequently performed task, as it had never been performed by the participants. To summarize, it was important to illustrate that there were differences between the tasks, however more importantly that Vetkoek was less familiar than the other tasks and had never been made by the participants (see Figure 2).

Demographics questionnaire. Participants filled out a demographics questionnaire that was adapted from the traditional CREATE (Center for Research and Education on Aging Technology Enhancement) demographics form illustrated in Appendix O (Czaja et al., 2006). Four additional questions were added to elicit additional information about the participants' education and background in task analysis. The additional questions were: what year the participants were in school, what their major was, if they had taken any task analysis related classes such as ISYE, Psychology, or Computer Science, and finally if the participants had any experience with task analysis.

Exit questionnaire and debriefing. Following the task analyses, participants received an extensive exit questionnaire that served multiple purposes (Appendix P). First, the questionnaire gauged how much participants learned or how much declarative knowledge they gained about HTA from the instructional training. We asked the participants to list and briefly describe the five main features of HTA so that we could explicitly assess and compare what was learned in each experimental condition. The questionnaire also gauged the ease and difficulty of performing the task analyses to address where participants felt that possible errors were made.

Following the general questions regarding HTA and the analysis we included specific questions aimed at assessing the participants' familiarity with each task. Other questions included: using a 5-point Likert-type scale to rate the ease of performing the task (1= very easy, 5 = very difficult), rate your confidence in the analysis of the task (1=not confident, 5 = very confident), rate the frequency that you perform the task (1 = never, 5 = very frequently), and how the participant decomposed the task.

After covering specific task related questions, the questionnaire inquired about particular elements of HTA. The questions included how participants identified goals and subgoals, exhibited order of the elements, and how and when they decided to stop the task analysis. Finally, the questionnaire ended with general questions about participants' perception of the instructional material's effectiveness as well as participants' opinion of using task analysis to learn about a task.

Procedure

Participants were randomly assigned prior to the experiment to one of the three training conditions: procedural step instructions, a decision-action diagram, or a concept map. Once participants arrived for testing they were asked to thoroughly review and sign the informed consent illustrated in Appendix A. Once participant signed the consent form they began the experiment with a series of general ability tests that served to describe the participants.

First participants were tested for both near and far vision to ensure they had a minimum of 20/40 vision as determined by the Snellen acuity test. Then participants completed a series of abilities tests: the Digit – Symbol Substitution test that examined their perceptual speed (Wechsler, 1997), followed by the Reverse Digit Span which tested participants' memory span (Wechsler), and finally the Shipley Vocabulary test that examined verbal ability (Shipley, 1940). The general flow of the study is outlined in Figure 3. To gauge participants' initial knowledge base on the topic of task analysis, they were asked to perform a task analysis of how to make toast without any instructions.

Upon completion of the introductory task analysis, participants read the initial instructions of the experiment containing a real world scenario in which HTA may be applied. Following these instructions participants read the general information packet (as adapted from Shepherd, 2001). Once participants indicated they were done reading the general information they were asked to re-read the information to ensure full comprehension. Participants were required to spend 15 minutes on the introduction.

After the second read through of the general introduction to HTA the participants received further information that differed depending on the experimental conditions participants were assigned to. The experimenter read aloud the introduction to the training condition while the participants read along. Once the experimenter read the additional instructions the participants had 15 minutes to review all the material. After the 15 minutes ended participants received their first task to analyze. The instructions were available for the participants as they performed the task analyses so that they did not have to rely on memory. The participants had a maximum of 15 minutes to conduct the task analysis. Once they completed the first analysis of the counterbalanced tasks the experimenter instructed the participants to continue with the second and then third task. Each task analysis was allotted a maximum of 15 minutes, but the average time participants spent on the analyses was 7 minutes.

Following the task analyses of the three counterbalanced tasks participants received a short break and used this time to fill out the demographics questionnaire (Appendix O) and the contact information sheet for administrative laboratory purposes. Upon completion of the information sheet (which took about 5 minutes to complete) participants conducted a task analysis of the final task: making the dish Vetkoek (a South African main course) (Appendix L) for which participants again had 15 minutes. Once the final task analysis was completed participants filled out an exit questionnaire and were given a debriefing sheet that the experimenter read aloud. Once the debriefing was complete, participants exited the experiment and received course credit on Experimetrix.

Results

An in-depth qualitative data analysis was performed on the questionnaires and task analyses. First, we coded the questionnaires to assess the participants' declarative knowledge of HTA. These data comprise the first section of the results. Second, we coded the participants' task analyses to determine their procedural knowledge of HTA. These data are reported in the second section of the results. Inter-rater reliability was established for each coding.

Declarative Knowledge

The questionnaires were analyzed to assess participants' declarative knowledge of HTA. This involved coding the first question of the questionnaire "Please list and describe the five main features of Hierarchical Task Analysis". This question assessed what participants learned about HTA through training as well as how accurate they were at reporting what they learned.

Coding scheme and reliability. The questionnaires were coded on the five main features of HTA that we recognized as the most important, based on the study conducted by Patrick and colleagues (2000) and adjusted to fit our study. An individually listed feature was defined as one segment. Because each of the 18 participants identified 5 features, there were a total of 90 segments. A segment was either coded on one of the five features listed in Table 3 or if it did not fit in any of the categories, it was coded as "other".

Two coders coded the segments to ensure inter-rater reliability. First, the coders coded two participants' answers to establish reliability. Once reliability was established, the remaining answers were coded by both coders. Any disagreements between coders were discussed and resolved. Inter-rater reliability was calculated using Cohen's Kappa and was determined to be 0.81 which is greater than the 0.8 necessary for satisfactory reliability (Cohen, 1960).

Accuracy of the main features. The maximum number of correctly identified features was five per participant. Although all participants listed five features, these features were not all different. Five participants mentioned the same feature twice. A duplicate was not counted as correct but was coded as "other". Half of the features identified by participant were correct to the coding criteria and the other half of the features were coded as "other." The mean overall accuracy was 50% (*SD* = 38.2%). The mean accuracy of the decision-action diagram condition was the highest with 57% (*SD* = 40%), compared to the procedural steps condition with 46.6% (*SD* = 43%) and the concept map condition with 46.6% (*SD* = 39.8%).

We expected no differences in the accuracy of reporting the five features between experimental conditions because there was no difference in the general information given to the experimental conditions. An omnibus Chi-square test was performed to test this hypothesis and confirmed that no significant differences between experimental groups in the distribution of the scores were found ($\chi^2 = 4.4, 8, p = .818$). Table 4 shows the total number of correctly identified main features and other features by experimental condition.

In addition to determining the overall accuracy it was important to identify what types of errors were made. An error was defined as not correctly identifying one of the main features. We first performed a Chi-Square analysis to determine if there were significant differences in how frequently the five features were mentioned in relation to the maximum expected accuracy. The results showed that there is a significant difference between the main features ($\chi^2 = 33.1, 4, p < .001$), and judging from the residuals, two features contributed significantly to this finding: hierarchical representation and satisfaction criteria.

A second chi-square analysis was conducted in which the expected value was based on the actual number of answers to determine which categories were over and under-represented based on the total number of answers. Results showed a significant difference between categories ($\chi^2 = 21.1, 4, p < .001$). Again looking at the residuals, participants identified the hierarchical approach and criteria least often and stating subgoals most often. Taken together, these findings show that in addition to not mentioning the hierarchical approach, participants also made the error of not mentioning the satisfaction criteria as a defining feature of HTA. These were the two most frequently made errors when identifying the five main features of HTA. These findings are interesting seeing that a hierarchical representation is one of the most fundamental features of HTA.

Additional learning. One interesting finding pertains to comparing the total number of segments coded as one of the five features to the total number of segments that were coded as "other". Here we found that half of the answers were coded on one of the five features as elaborated above, and the other half were coded as "other". This means that participants identified concepts that are characteristic of HTA but were not included in the five main features of HTA as we defined them. We decided to further explore the segments coded as "other" and found a number of distinct patterns within the segments. From these patterns we created five sub-categories of the code "other": stating a purpose, gathering data, task boundaries, revise analysis, and terminate analysis (Table 5).

From the "other" category we found that 68% of the segments fit into the additional 5 categories we established and the remaining "other" segments had no identifiable pattern. Terminating or stopping the analysis was mentioned most often by all three conditions. This was followed by stating the purpose of the analysis and gathering data, however, the decision-action diagram did not mention either of these. Therefore, we were able to find some differences between groups: the decision-action diagram group only identified features that could be coded as terminate or revise and produced the most segments that were not categorizable. Looking back at the differential instructional materials we determined that the patterns found in the "other" features were partially a function of the information found in each condition and therefore the instructions must be revised for further experimentation. Additionally, it is important to keep in mind that these "other" features are important to HTA but do not overlap with the five main features that we identified.

Procedural Knowledge

Coding scheme and reliability. To assess the procedural knowledge we coded each task analysis developed by the participants. We used an extensive coding scheme that can be seen in Appendix (N). Parallel to coding the declarative knowledge we coded on the five main features of HTA: hierarchical approach, state high-level goal, state subgoals, state plan, and satisfaction criteria. Additionally, we coded the extra categories of generalizability, the number of “if, then” statements, and the number of “decide” statements. These extra categories were coded to gain additional information about the task analyses and how the participants applied the instructions to performing the task analyses. Generalizeability was coded to determine if the assumption that HTA is a general form of task analysis holds true in our study, and the number of if-then and decide statements were coded to determine if the task analyses were more action or goal oriented (see Table 6 for the coding scheme).

Two coders coded all task analyses. We determined the order of coding by using a random number generator, and coded the task analyses separately using the coding booklet that documented the specific categories and examples we established (Appendix M). Initially, coders compared their coding after every two participants until an average of 80% agreement was established. Any disagreements between coders were discussed and resolved to ensure inter-rater reliability. Inter-rater reliability was calculated by percent agreement and was determined for each of the five tasks: Toast (93.6%), coffee (86.9%), door (85.2%), phone (80.2%), and Vetkoek (86.4%).

Hierarchical representation. The main feature of hierarchical representation was coded on both the breadth and depth of the task analysis. Breadth was determined as the number of elements stated on the highest level of the task analysis, whereas depth was determined as the maximum number of levels the task analysis was deep. To determine whether conditions significantly differed on the hierarchical representation we conducted a repeated measurement ANOVA for both breadth and depth. The results for breadth showed that there was no significant interaction between task and condition (p=.783), nor was there a main effect of condition

(p=.279). There was, however, a main effect of task ($p < .001$). Additionally, comparing the means of each task between experimental conditions shows an observable trend; participants in the procedural steps condition created the narrowest task analysis with a mean of 5.2 (*SD* = 2.6) elements wide, decision-action was in the middle with a mean of 6.2 (*SD* = 3.4) elements, and the concept map condition had the broadest task analyses with a mean breadth of 7.3 (*SD* = 3.2) elements.

The same set of data analyses on the depth of the task analysis showed that there was no interaction of task and condition (p =.752), nor was there a main effect of condition (p=.633). There was a main effect of task ($p < .001$). We also looked at the observed depth means for a trend and saw smaller differences between experimental conditions than with breadth. The procedural steps group had the highest mean (thus a deeper hierarchy of closer to 2 levels) for tasks with 1.7 (*SD* = 1.0), concept map followed with a mean of 1.5 (*SD* = 0.5), and decision-action had the lowest mean with 1.4 (SD = 0.6). However, across the groups, participants only went to maximum two levels deep in the hierarchy.

High-level goal. The second feature we coded on was stating the high-level goal. The trends of the counts showed that the decision-action diagram condition was highest in identifying the high-level goal with 77% of the task analyses, followed by the concept map condition with 73% and procedural steps with the lowest at 53%. We analyzed the counts by using crosstabs and a Chi-square analysis. Results indicated that there were no differences in the stating the high-level goal between experimental conditions for all tasks except for phone. The Chi-square analysis showed that the task of making a phone call was significantly different between conditions ($\chi^2 = 7.2, 2, p = .027$). Additionally, we found that there was a significant increase in the number of times the high-level goal was stated when comparing the task of making toast and the other four tasks (χ^2 = 14.2, 4, p <.01). This indicates that there was a gain in procedural knowledge about stating the high level goal through the instructions. In addition, the procedural knowledge about stating the high-level goal confirms the finding of the declarative knowledge about the meaning of the high-level goal.

Plan. Next, we coded the task analyses on whether or not they included a plan. We looked for both the statement of the label ‘plan’ as well as the style that participants used to express the order and sequence of the plan. Chi-square analyses were conducted to determine significant differences between conditions. The results however could not be calculated because there were fewer than five counts across all conditions. We then conducted a within tasks Chi-square analysis. Results indicated that the plan label when creating a task analysis of making Vetkoek was significantly different from the other tasks (χ^2 = 55.7, 4, p = .05), and there was significant improvement in stating the plan in subsequent task analyses for the decision-action and concept map conditions. Data analysis also showed that participants in the procedural steps condition never mentioned the plan label, and therefore we can say that they did not learn about specifying the plan in their condition. The concept map condition on the other hand mentioned the plan label in 43% of the task analyses and the decision-action diagram condition mentioned it in 23% of the analyses.

The plan style itself was identified as one of the following: bulleted list, numbered list, list other, paragraph/text, picture, flowchart, or combination. Generally, there was a large variety of styles. As shown in Table 7, numbered list was used most often by all conditions; it was used 31% of the time. Lists in general accounted for 59% of the styles used and approximately 66% of the combination styles involved a list. The concept map condition clearly favored numbered lists followed by paragraphs and flowcharts. Participants in the decision-action however did not have a clear preference, as all styles were represented almost equally (numbered lists were represented slightly more). Finally participants in the procedural steps condition most often used a combination of styles, followed by numbered lists.

Subgoals. An important feature of HTA is subgoals. We analyzed the representation of subgoals by examining the label "subgoal" as well as by comparing participants' task analyses with the high level goals of our master task analyses. Chi-square analyses could not be computed because there were not enough counts in the conditions. We did notice, however, that compared to the task of toast there was an increase in the mentioning of the subgoal label for the four other tasks. Additionally, we noticed that when comparing the statement of the plan label with subgoal label, the procedural steps condition learned more about subgoals.

To analyze the specific goals, we coded the subgoals identified in the task analyses to those that we identified in our master task analyses. Table 8 shows the total number of goals identified per condition and task. A Chi-square analysis indicated that there were no significant differences between conditions in the overall number of goals identified ($\chi^2 = 3.34$, 3, $p = .911$), however there are observable trends. The concept map condition identified more subgoals overall than either the procedural steps or decision-action diagram conditions.

We also conducted a Chi-square analysis to determine whether or not the observed counts differed between tasks as there was an observable pattern. The Chi-square analysis confirmed the trend and significant differences were found between tasks ($\chi^2 = 32.3$, 4, $p < .01$). Participants identified substantially fewer subgoals with the task of toast than with the other four task analyses, and the task analyses of coffee and door identified more subgoals than the other tasks. Overall, we found that the training was effective in increasing the number of goals identified.

It is also interesting to look at what specific subgoals were identified. The tasks of making toast, coffee, and Vetkoek were analyzed using master task analyses with the same general goal structure, and thus we compared the results of these three first (Table 9). Results clearly indicated that these task analyses focused on the subgoal of following the recipe most and the lower-subgoals associated with it. Additionally it is interesting to point out that participants attributed 16% and 13% of their subgoals of the tasks of toast and coffee to preparing technology, but only 2% were applied to technology in the task of making Vetkoek. This indicates that the more familiar tasks of making toast and coffee provided for more action oriented task analyses whereas the less familiar task of making Vetkoek provided a more goal oriented task analyses. Finally, it is worth pointing out that participants focused most of their attention to lower-level subgoals of these three tasks when performing the analyses; 97% of all counts were lower-level goals in toast, 95% to coffee, and 76% in Vetkoek.

The task analyses for painting a door were also analyzed to determine what subgoals participants focused on most. The subgoal of applying the paint coat was most often identified (46%), followed by getting materials (20%), and determining materials (11%). The remaining counts were distributed to the four remaining subgoals of preparing the door, placing it in position, protecting the door, and wrap up (clean up and reorient the door), and it can be seen that these were extremely underrepresented. Additionally, 93% of all counts were attributed to the lower-level subgoals. (Refer to table in Appendix R**).**

The task analysis of making a phone call had the most equalized distribution of subgoals identified. Participants focused most on making a connection (43% of the subgoals), followed by obtaining the phone (21%), ending the call (14%), communicate (11%), and determining the receiver (10%). However, once again the participants identified the subgoals on a lower-level with 98% of the overall counts being on the lower-level. **(**Refer to table in Appendix S**).**

Satisfaction criteria. The final feature we analyzed was mentioning satisfaction criteria. Once again a crosstabs and Chi-square analysis was conducted on these counts. The results showed no differences between conditions for all tasks ($\chi^2 = 4.13, 3$, $p = .845$), but there were observable trends. The concept map condition identified satisfaction criteria the most (67%), followed by decision-action diagram (57%), and finally procedural steps at 53%. In addition, there was an increase seen in the mentioning of the criteria from the first task of making toast to the other tasks, indicating that participants did learn the procedural knowledge of stating satisfaction criteria.

Coding extra categories. Besides coding the five main features we also chose to code on the overall generalizeablity of the task analysis. It is an assumption of HTA that the task analyses produced are general representations of the tasks, and therefore we coded to determine if this held true for the task analyses produced in this experiment. Generalizability meant evaluating whether or not specific technologies were mentioned. Results of the coding indicated that all conditions were specific. The procedural steps condition was 83% specific; the concept map condition had 76% specificity, and decision-action diagram 73% specificity. A Chi-square analysis could not be conducted because there were not enough counts in the conditions. It is important to acknowledge that the only two tasks that produced task analyses that were coded as general were making a phone call and Vetkoek. It was expected that the task analyses for Vetkoek would be more general due to a lack of familiarity. However it was not expected to see that the phone was also less technologically specific. One explanation might be that since participants have used a large a variety of telephones, they do not have one specific way of making a phone call.

The final two additional criteria we coded on were the number of if-then statements and the number of decide-statements. These two criteria were added through top-down analysis and found to have been mentioned very little throughout the task analyses. The number of if-then statements was higher for decision-action diagram and concept map conditions than for procedural steps (with means of 1.5 (*SD* = 1.9), 1.7 (*SD* = 2.3), and 0.5 (*SD* = 0.8) respectively) and a repeated measures analysis was conducted and found a significant main effect of task ($p < .05$). However we found no significant interaction between tasks and condition (p=.493) no main effect of condition (p= .585). The decide-statements had an even lower impact on the task analyses as there was only one participant in the decision-action diagram condition who mentioned decide statements.

Self-perception. Following the questions about HTA, participants were asked to rate for each task the ease of performing the task analysis and participants' confidence in the final product. Ease of performing the task was rated on 5-point Likert-type scale (1= very easy, 5= very difficult) as with the confidence of performing the task (1 =very easy, 5=very difficult).

We performed a repeated measures ANOVA to determine if there were differences in the groups between tasks. No interaction was found between groups and tasks for either ease of performance ($p = .75$) or confidence ($p = .38$). Furthermore, there was no significant main effect of group for either ease of performance ($p = .63$) or confidence ($p = .81$). However, there was a main effect of task for both ease of performance ($p < .01$) and confidence ($p < .01$). Yet again, the effect of task was a stronger indicator than experimental differences between the groups.

Discussion

The goal of this study was to understand how different types of instructions influence declarative and procedural knowledge acquisition of HTA. What content do novices learn, and what errors do novices make as a function of instructional material that employed different types of spatial diagrams (matrix, network, hierarchy) and task familiarity? Results indicated that there were no significant differences between experimental conditions on acquisition of declarative or procedural knowledge. However there were a number of observable trends between experimental conditions as well as significant differences between tasks and main features of HTA. More specifically declarative knowledge assessment focused on what participants identified as the main features of HTA. Overall, participants' accuracy was around 50% and it can be concluded that generally speaking, the instructions were effective in providing general information about the main features of HTA. More specifically, almost all participants understood the importance of stating the high-level goal and subgoals to HTA, however participants did not recognize the hierarchical representation or stating satisfaction criteria as defining features of HTA. Additionally 50% of the features identified by participants as important to HTA pertained to other aspects of HTA. Experimental conditions differed in specific wording in the additional instructions and thus some of the other aspects were not equally distributed between conditions. These findings contribute to our understanding of the specific knowledge novices may take away from a brief introduction to HTA.

In addition to the declarative knowledge, the procedural knowledge analysis found no significant differences between experimental conditions, but again we do see observable trends. The task analyses were coded on the same criteria as the declarative knowledge. All five of the criteria we coded on (hierarchical representation, stating high-level goal, subgoal, plan, and satisfaction criteria) showed differences between the tasks. Further analysis of subgoals indicated that the task of making a piece of toast did not include as many subgoals as the task analyses of the other four tasks, and the tasks of coffee and door identified the highest number of subgoals.

Ultimately our study corroborated Patrick and colleagues (2000) first study about the errors made in learning HTA. We identified that participants made specific errors in not identifying hierarchical representation or satisfaction criteria as important to HTA. Additionally we found that participants committed numerous errors when they stated features about HTA other than the five main features we established. However, it is important to note that although the additional features they mentioned were not included in our five main features, they were still other important aspects of HTA.

Our findings added to those identified by Patrick and colleagues (2000) but whose interpretation were limited because of limitations in the design that we identified (e.g., inconsistent time allotted to each condition, only analyzing one task analysis for each participant). Patrick and colleagues did a wonderful job describing the coding categories. Our results expanded on those found by Patrick and colleagues. With the addition of four more task analyses per participant we had a total of 90 tasks task analyses to analyze and compare across conditions. We added rigor to the data analysis process by developing a master task analysis that allowed standardization and comparison.

This study however, did not find differential effects of the different visual representations used in our training conditions on knowledge acquisition at the initial stage of learning. Instead we found that at this initial stage of learning, task characteristics had stronger influences on knowledge acquisition. In order to understand the effects of different training procedures on knowledge acquisition, future studies must be conducted to include more practice on HTA and more time spent with the instruction.

Conclusion

Overall this study has numerous implications for early stage learning of HTA. Through the comparison of three different training conditions (procedural steps, decision-action diagram, and concept map) we found that the effect of task was much stronger than the effect of training conditions at this level of learning. Participants did learn something from the training, but for appropriate declarative knowledge to be acquired we must provide further training than just general instructions when training novices. Additionally it is important and useful to assess if procedural knowledge confirms declarative knowledge understanding. This study indicated that for these specific training conditions, the procedural knowledge of stating high-level goal and subgoals confirmed the declarative understanding. However it is important that novices obtain a complete understanding of *all* features of HTA on both the declarative and procedural level.

Learning trends were also identified between the conditions. The concept map condition learned the most about the importance of subgoals, the decision-action diagram recognized stating the high-level goal as most important, and the procedural steps condition failed to learn the plan label. These differences are important to acknowledge as it is possible that participants attenuated more to certain parts of the instruction than others, but it is also possible that the differences in the wording of the instructions may have lead to different knowledge acquisition. In order for further investigation of training of HTA to continue, the specific training materials must be refined to ensure that the information is the same between conditions. The findings of this study will add to the current research on HTA and diagrams used to illustrate, and serve to focus more attention on specific types of training HTA.

References

Anderson, J. R. (1996). A simple theory of complex cognition. *American Psychologist, 51*(4), 355-365.

Annett, J., & Duncan, K. D. (1967). Task analysis and training design. *Occupational Psychology, 41*, 211-221.

Annett, J., Duncan, K. D., Stammers, R. B., & Gray, M. J. (1971). *Task analysis.* Department of Employment Training Information Paper 6. HMSO, London.

Annett, J. (2004). Hierarchical task analysis. In: D. Diaper and N.A. Stanton (Eds.) *The Handbook of Task Analysis for Human-Computer Interaction*. pp. 67-82. New Jersey: Lawrence Erlbaum Associates.

Astley, J. A., & Stammers, R. B. (1987). Adapting hierarchical task analysis for user-task interface design. In J. R. Wilson, E. N. Corlett and I. Manenica (Eds.), *New Methods in Applied Ergonomics*, pp. 175-184. London: Taylor & Francis.

Bhowmick, A., Khasawneh, M., Bowling, S., Gramopadhye, A., & Melloy, B. (2007). Evaluation of alternate multimedia for web-based asynchronous learning. *International Journal of Industrial Ergonomics, 37*(7), 615-629.

Cohen, J. A. (1960). Coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*, 37–46. Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging, 21*, 333-352.

Eppler, M. J. (2008). A processed-based classification of concept maps and application examples. *Knowledge and Process Management, 15*(1), 59-71.

Kirwan, B. & Ainsworth, L. K. (1992). *A Guide to Task Analysis*. London: Taylor and Francis.

McGrew, J. F. (1997). A comparison of three methods of task analysis: cognitive analysis, graph-matrix analysis, and self-organizing networks. *International Journal of Human-Computer Interaction, 9*(1), 41-57.

McLaughlin, A., Rogers, W., & Fisk, A. D. (2008). Feedback support for training: accounting for learner and task. *Proceedings of the Human Factors and Ergonomics Society 52nd Annual Meeting. San Antonio*

Michas, I., & Berry, D. (2000). Learning a procedural task: effectiveness of multimedia presentations. *Applied Cognitive Psychology, 14*(6), 555-575.

Novick, L. R. (2006) Understanding spatial diagram structure: An analysis of hierarchies, matrices, and networks. *The Quarterly Journal of Experimental Psychology, 59*(10), 1826-1856.

Patrick, J. (1992). *Training: Research and Practice.* London: Academic Press.

Patrick, J., Gregov, A., & Halliday, P. (2000). Analysing and training task analysis. *Instructional Science*, *28*(1), 51-79.

Shepherd, A. (1985). Hierarchical task analysis and training decisions. *Programmed Learning and Educational Technology*, *22*, 162-176.

Shepherd, A. (1993). An approach to information requirements specification for process control tasks. *Ergonomics, 36*, 805-817.

Shepherd, A. (2001). *Hierarchical Task Analysis*. New York: Taylor and Francis.

Shipley, W. C. (1940). A self-administering scale for measuring intellectual impairment and deterioration. *Journal of Psychology, 9*, 371-377.

Stanton, N. (2006). Hierarchical task analysis: Developments, applications, and extensions. *Applied Ergonomics, 37*, 55-79.

Vail, E. F. (1999). Mapping organizational knowledge. *Knowledge Management Review 2* (8), 10-15.

Wechsler, D. (1997). *Wechsler Memory Scale III*. (3rd Ed.). San Antonio, TX: The Psychological Corporation.

Table 1:

Participant Characteristics (N = 6 per condition)

Group	Procedural Steps		Decision-Action		Concept Map	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	20.6	1.3	20.6	1.1	20.0	1.3
Digit Symbol Substitution	9.3	3.2	7.9	1.1	9.3	2.9
Digit Symbol Recall	75.1	13.4	70.4	11.4	71.8	13.4
Reverse Digit Span	9.0	0	6.3	3.3	6.5	3.7
Shipley Vocabulary	32.9	2.0	31.9	1.3	32.2	4.1

Table 2:

Means and Standard Deviations of Ratings for Familiarity and Frequency

	Making Toast		Making a Cup of Coffee		Making a Phone Call		Painting a Door		Making Vetkoek	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Familiarity	4.8	0.1	3.2	0.42	5.0	0	2.8	0.25	1.0	0
Frequency	3.7	0.2	2.7	0.39	4.8	0.2	1.6	0.12	1.0	0

Table 3:

Coding Criteria for the Five Main Features of HTA

Main feature of HTA	Description	Example
1. Hierarchical representation	The number of levels the TA will have	"Create hierarchical task analysis"
2. State high level goal	The main goal to be achieved	"Goal – what the desired outcome might be"
3. State plan	The order or sequence in which the task is to be carried out	"Have a plan"
4. State subgoals	The sub-elements necessary to carry out the high-level goal	"Breaking the goals into subgoals"
5. State satisfaction criteria	The criteria that establish if the task has been properly completed	"Ensure the final goal is satisfied"

Table 4:

Accuracy of Identified Features of HTA By Experimental Condition (N=6 per Condition*)*

	Experimental Condition				
	Procedural Steps	Decision/ Action	Concept Map	Sum	Maximum
Hierarchical Approach	0	0	1	1	18
State High Level Goal	5	6	3	14	18
State Plan	2	4	4	10	18
State Subgoals	6	5	6	17	18
State Satisfaction Criteria	1	2	0	3	18
Sum	14	17	14	45	90
Other	16	13	16	45	

Table 5:

Further "Other" Segment Coding

Condition	Procedural Steps	Decision/ Action	Concept Map	Sum
State Purpose	3	0	3	6
Gather Data	2	0	4	6
Task Boundaries	2	0	1	3
Revise Analysis	0	3	1	4
Terminate Analysis	4	3	2	9
Not Categorizable	3	6	4	13

Table 6:

Summary of Procedural Knowledge Coding Scheme

Main feature of HTA	Description	Examples
1. Hierarchical representation	a. Breadth at first level b. Depth at maximum level	
2. State high level goal	a. Mentioned b. Not Mentioned	a. "Making a phone call"
3. State plan	Plan Label: a. Mentioned b. Not Mentioned Plan Style: -Bulleted list, numbered list, etc.	 a. identify "plan" in TA b. no identification of plan
4. State subgoals	Subgoal Label: a. Mentioned b. Not Mentioned Code on High level Master TA	 a. "subgoal, sub-operation" b. no identification of subgoal
5. State satisfaction criteria	a. Mentioned b. Not Mentioned	a. "ensure proper temperature"
Extra		
6. Generalizeable	a. General b. Specific	a. No mention of technology b. Mentions specific technologies

7. "If, then" statements	Number of if-statements
8. Decide statements	Number of decide-statements

Table 7:

Counts of Plan Styles

	Experimental Condition				
Plan Style	Procedural Steps	Decision/ Action	Concept Map	Count	%
Bulleted List	5	4	2	11	12%
Numbered List	7	8	13	28	31%
List Other	5	7	2	14	16%
Paragraph/text	5	2	5	12	13%
Picture	0	1	0	1	1%
Flowchart	0	3	5	8	9%
Combination	8	5	3	16	18%

Table 8:

Overall Counts of Subgoals by Condition and Task

	Experimental Condition			
Tasks	Procedural Steps	Decision/ Action	Concept Map	Sum
Toast	39	33	41	113
Coffee	54	69	72	195
Door	55	53	72	179
Phone	41	38	52	131
Vetkoek	42	44	48	134
Sum	231	237	284	752

Table 9:

Overall Counts of Subgoals for Toast, Coffee, and Vetkoek

Subgoals (from master TA)	Toast	Coffee	Vetkoek
Get recipe	0	0	4
1x.	0	0	19
2. Follow Recipe	0	0	7
2x. (preparing technology)	87 (16)	74 (13)	51 (2)
3. Serve	1	1	7
3x.	8	17	5
4. Enjoy dish (eat/drink)	2	5	2
4x.	0	1	0
5. Wrap Up	0	0	0
5x.	2	3	1
Other Goals	1	0	1
Sums	100%	100%	100%

Note: 1x, 2x, 3x, 4x, and 5x refer to goals on a lower level

1: Toast
2: Coffee
3: Door
4: Phone
5: Vetkoek

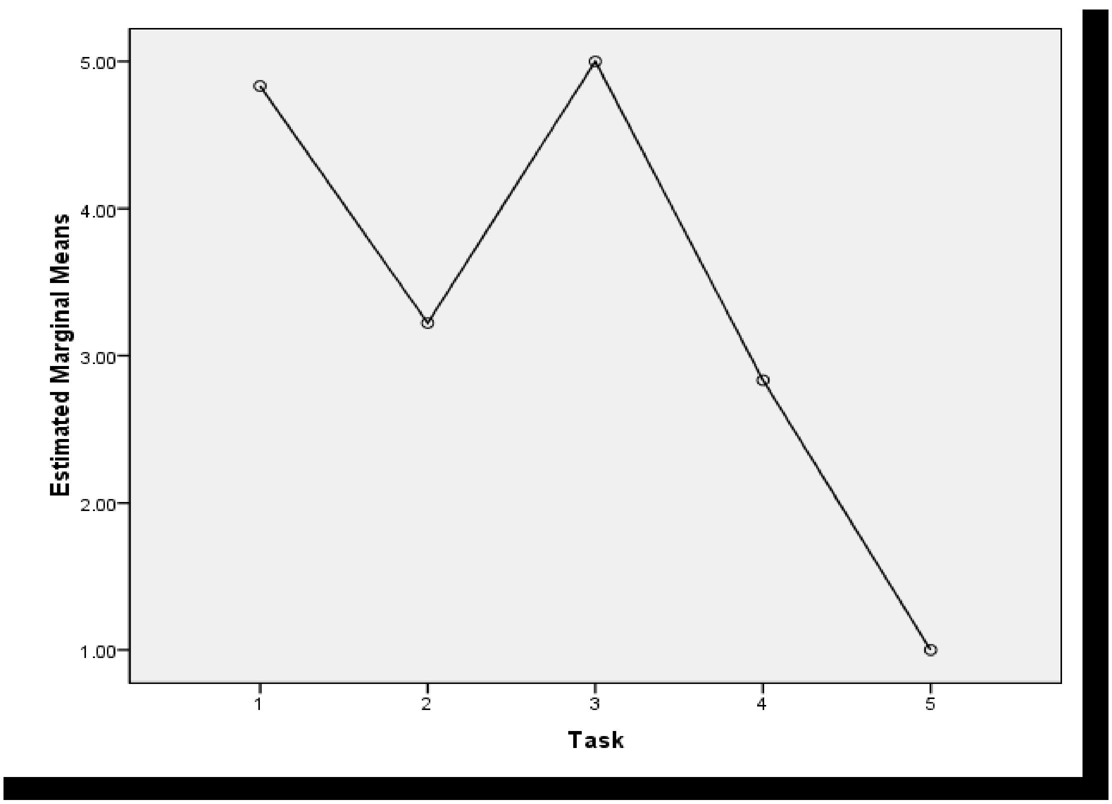
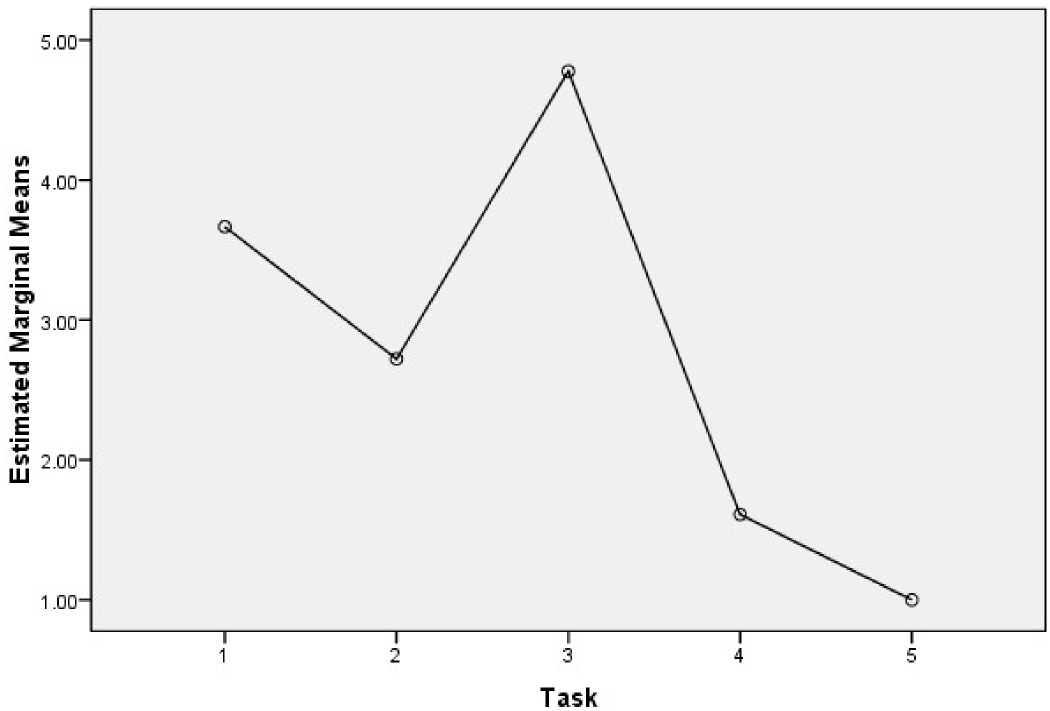


Figure 1: Familiarity ratings for the five tasks

1: Toast
2: Coffee
3: Door
4: Phone
5: Vetkoek



[redacted]

Figure 2: Frequency ratings for the five tasks

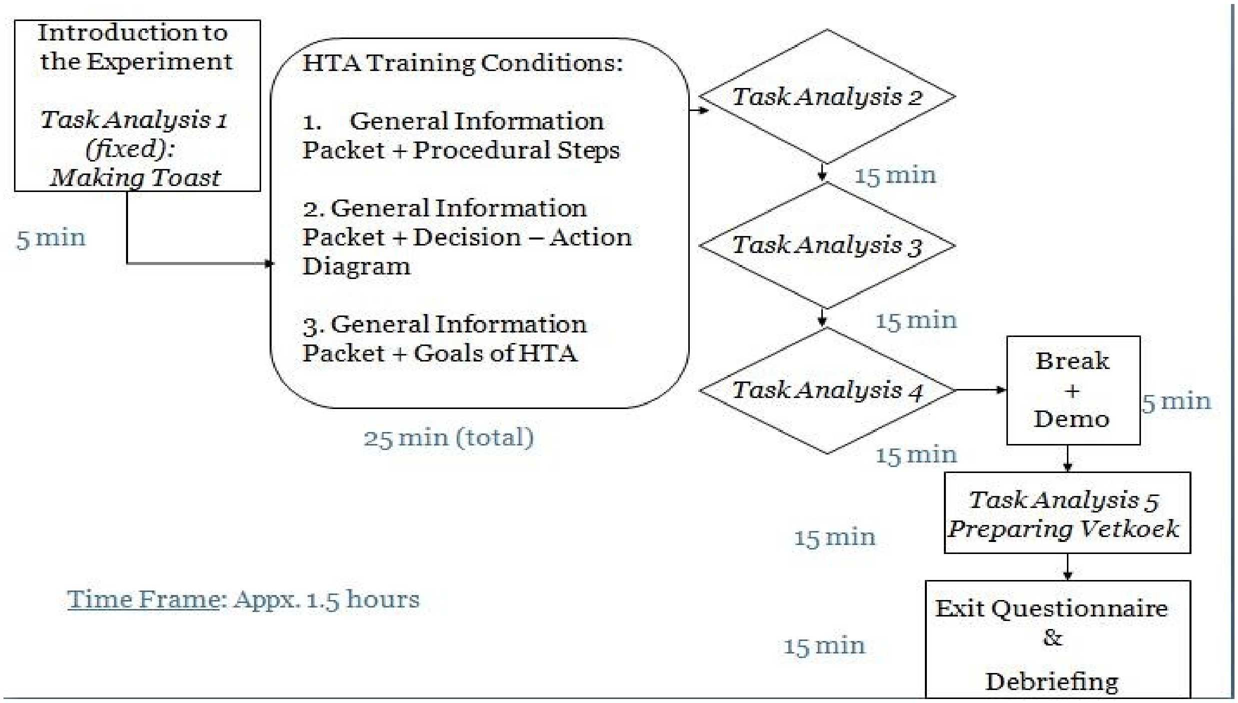

Introduction to the Experiment
Task Analysis 1 (fixed): Making Toast
5 min
HTA Training Conditions:
1. General Information Packet + Procedural Steps
2. General Information Packet + Decision – Action Diagram
3. General Information Packet + Goals of HTA
25 min (total)
Task Analysis 2
15 min
Task Analysis 3
15 min
Task Analysis 4
15 min
Break + Demo
5 min
Task Analysis 5 Preparing Vetkoek
15 min
Exit Questionnaire & Debriefing
15 min
Time Frame: Appx. 1.5 hours

Figure 3: Experimental flow

List of Appendices

M: Procedural Knowledge Coding Booklet

N: Counterbalance of Systems

O: Demographics

P: Exit Questionnaire

Q: Debriefing

R : Distribution of Subgoals : Door

S : Distribution of Subgoals : Phone

Appendix A: Consent Form

Georgia Institute of Technology

Project Title: *Training Novices on Hierarchical Task Analysis*

Investigators: Dr. Arthur D. Fisk & Dr. Wendy A. Rogers (Principal Investigators) – Sarah K. Felipe & Anne E. Adams (Student Investigators)

Research Consent Form (v.1 – March 5, 2009)

Purpose

You are being asked to be a volunteer in a research study. The purpose of this form is to tell you about the tasks you will be asked to complete today and to inform you about your rights as a research volunteer. Feel free to ask any questions that you may have about the study, what you will be asked to do, and so on.

Thank you for your interest in participating in the study. Our work could not be completed without the help of volunteers. The purpose of our research is to provide us with insight into the effectiveness of different types of instructions on performing a Hierarchical Task Analysis. We expect to enroll 40 people in this study.

Exclusion/Inclusion Criteria

Participants in this study must be between the ages of 18 and 28 years, native English speakers, and novices in performing task analysis.

Procedures:

If you decide to be in this study, your part will involve taking a number of general tests that measure your abilities including vision, speed of responding, memory, and vocabulary. Following the general tests we will ask you to start with a sample task analysis. Then you will be given information regarding task analysis and asked to perform the actual analysis on a number of tasks. We will also ask you to complete a questionnaire about your experience in this area.

Remember that you will be given full instructions on every task. It is important that everyone understands the instructions before beginning the tasks. Because we are trying to obtain a range of measures, some of the tasks are very simple, and others a little more difficult. If anything is unclear at any time, please do not hesitate to ask questions. This one-session study will take no more than 2 hours. You may stop at any time and for any reason.

Risks/Discomforts

The following risks/discomforts may occur as a result of your participation in this study. Participation in this study involves minimal risk or discomfort to you. Risks are minimal and do not exceed those of normal office work. Please tell us if you are having trouble with any task.

Benefits

You are not likely to benefit in any way from joining this study. But we hope that others will benefit from what we find in doing this study.

Compensation to You

You will receive 1 hour of extra credit for each hour you spend in the study. The time to complete the study is approximately 2 hours, so you will receive 2 hours of extra credit. If you withdraw from the study early for any reason, you will receive 1 credit per hour for your time.

Confidentiality

The following procedures will be followed to keep your personal information confidential in this study: The written data that are collected about you will be kept private to the extent allowed by law. To protect your privacy, your written records will be kept under a code number rather than by name. Your written records will be kept in locked files and only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published.

Confidentiality cannot be guaranteed; your personal information may be disclosed if required by law. This means that there may be rare situations that require us to release personal information about you, for example, in case a judge requires such release in a lawsuit or if you tell us of your intent to harm yourself or others (including reporting behaviors consistent with child abuse).

To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB will review study records. The Office of Human Research Protections may also look at study records.

Because each individual's data and test scores are completely confidential, we cannot mail your individual results.

Costs to You
There are no costs to you associated with participating in this study.

In Case of Injury/Harm

If you are injured as a result of being in this study, please contact Dr. Arthur D. Fisk at 404-894-6066 or Dr. Wendy A. Rogers at 404-894-6775. Neither the Georgia Institute of Technology nor the principle investigators have made provision for payment of costs associated with any injury resulting from participation in this study.

Participant Rights

- Your participation in this study is voluntary. You do not have to be in this study if you do not want to be.
- You have the right to change your mind and leave the study at any time without giving any reason, and without penalty.
- Any new information that may make you change your mind about being in this study will be given to you.
- You will be given a copy of this consent form to keep.
- You do not waive any of your legal rights by signing this consent form.

Questions about the Study or Your Rights as a Research Participant

- If you have any questions about the study, you may contact the investigator listed below at 404-894-8344.
- If you have any questions about your rights as a research participant, you may contact Ms. Kelly Winn, Georgia Institute of Technology Office of Research Compliance at (404) 385-2175.

If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to be a volunteer in this study.

____
Participant Name (please print)

____
Participant Signature **Date**

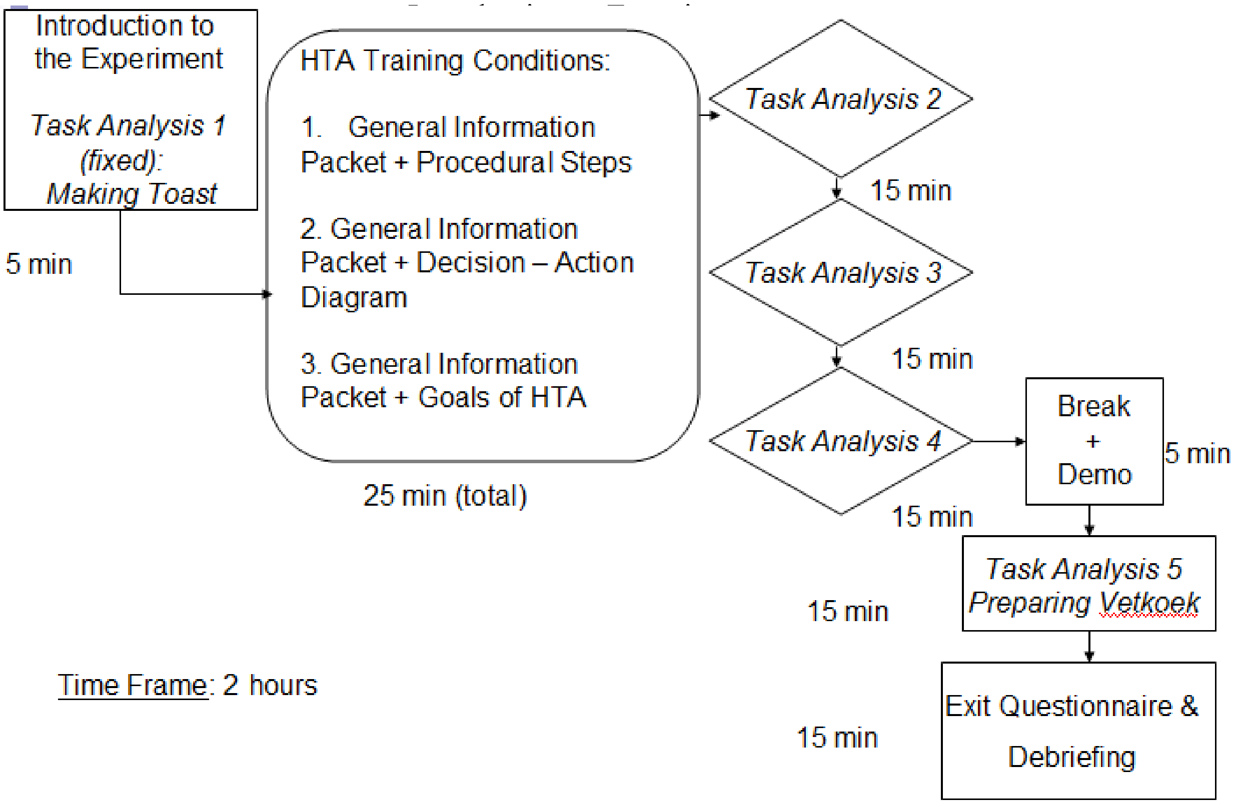
____
Name of Investigator Obtaining Consent (please print)

____
Signature of Investigator Obtaining Consent **Date**

Appendix B: Experimental Flow:

Appendix C: Instructions

to



Initial Instructions

Now, imagine that you are starting a new job and your boss asks you to analyze a variety of tasks using Hierarchical Task Analysis. You have no experience conducting a Hierarchical Task Analysis, but your employer provides you with a general information packet on conducting a Hierarchical Task Analysis. The packet includes a brief overview of the method and the decisions and plan, the steps involved, and the goals it is trying to accomplish. When I hand you the packet, please read through it. Once you feel that you have a good understanding of the information, please notify me. Do you have any questions at this point?

When Participants Finish:

I would like you read through and review the information again to make sure you have a good understanding of the method before you start applying it. You will have another 10 minutes to familiarize yourself. Do you have any questions at this point?

Instructions - Experimental Group 1: Procedure

The following list illustrates the main steps in conducting a HTA. Please study them carefully and consider them in addition to the information packet you read before you begin conducting your first Hierarchical Task Analysis.

You have 15 minutes to review the information. When you feel that you understand the concept of an HTA fully please notify me. Do you have any questions before we continue?

Instructions - Experimental Group 2: Decision/Action Diagram

The figure in front of you is a decision-action diagram of Hierarchical Task Analysis; it illustrates the flow of activities describing HTA and the decisions made while conducting the analysis. Please study them carefully and consider them in addition to the information packet you read before you begin conducting your first Hierarchical Task Analysis.

You have 15 minutes to review the information. When you feel that you understand the concept of an HTA fully please notify me. Do you have any questions before we continue?

.

Instructions - Experimental Group 3: Concept Map

Please examine the following figure illustrating the method and goals of the HTA. This diagram is a concept map that displays the various goals of HTA; defining goals/subgoals, stating the plan, redescribing goals into subgoals, determining the stopping point of the analysis (considering the width and depth of the analysis), defining the purpose of the analysis, and gathering data. Please study the concept map carefully and consider it in addition to the information packet you read before you begin conducting your first Hierarchical Task Analysis.

You have 15 minutes to review the information. When you feel that you understand the concept of an HTA fully please notify me. Do you have any questions before we continue?

Instructions - Conducting a Task Analysis

Now that you have been given both the general information packet and the additional handout on Hierarchal Task Analysis, I would like you to take that knowledge and apply it. Overall there will be three tasks to analyze in this portion of the experiment, and you will have 15 minutes to conduct each of the three task analysis.

First I would like you to perform a Hierarchical Task Analysis of (TASK 1 – read name of actual task). Once the 15 minutes have ended and you finished your task analysis, I will give you the next task to analyze.

Work to the best of your knowledge and understanding. Do you have any questions? <If not> Please begin your task analysis.

Instructions - Between Tasks

Thank you for completing the analysis of (name task). Now I would like you to conduct a task analysis on (name task two or three). You will again have 15 minutes for this analysis.

Do you have any questions? <If not> Please begin your task analysis.

Instructions - Break and Demographics

Thank you for completing the analysis of the tasks. You will have a 5 minute break. During this time please fill out the demographics questionnaire. When your 5 minutes have ended we will continue on to the final phase of the experiment.

Instructions - The Final Task

Now that you have had some time to practice conducting a Hierarchical Task Analysis we would like for you to conduct a final analysis on a task that is foreign to you. Please perform a Hierarchical Task Analysis of the following task: Preparing the Dish Vetkoek (a South African main course).

Do you have any questions before we continue? <If not> Please begin your task analysis.

Instructions - the Exit Questionnaire

Now that you have completed the task analyses, your final task for this experiment is to fill out this exit questionnaire. Please fill it out completely as we do value your opinion. Once you are finished, please return the survey to me.

Appendix D: General Information Packet

An Introduction to Hierarchical Task Analysis

Hierarchical Task Analysis (HTA) was first proposed in the late 1960s as a general approach to examining tasks. Since then, it has become widely adopted although the method is often applied untaskatically or in ways that fail to ensure its full benefit. The aim of this introduction is to present the ideas of HTA.

Any effort to improve human performance in a work or recreational setting must start by some understanding of what people are required to do and how they achieve their goals. Methods for achieving this understanding are often referred to as task analysis. Thus task analysis methods are an important prerequisite to the organization of work, the design of workplaces, work practices and equipment, and in helping people to master their tasks. Task analysis methods, therefore, should be of direct interest to managers and engineers concerned with setting up and organizing tasks, to designers concerned with making sure people can use equipment properly, to managers and supervisors concerned with making sure that tasks work according to design, to human factors and other management support staff concerned with prescribing conditions to enable people to work effectively, to human resource staff concerned with personnel and training issues, and to safety staff concerned to ensure that safe practices are followed.

In HTA, tasks are represented in terms of hierarchies of *goals* and *subgoals*, using the idea of *plans* to show when subgoals need to be carried out. In task analysis, it is always important to think of the reason why the task is carried out. For example, a toaster is used to obtain toast, by cooking ordinary bread to the satisfaction of the person who is to eat it. Thus the task has a purpose or goal and criteria against which the toast can be judged to be satisfactory or otherwise. Setting the criteria for industrial, commercial and service goals includes specification of the product and constraints on how it is achieved. These constraints can include cost and safety criteria. Thus, motor cars are manufactured to be capable of transporting passengers according to the criterion of speed and acceleration, but this cannot be achieved at the expense of comfort and safety.

Detailed criteria can rarely be specified at the outset of a design process, even in product design. As designs are developed and intermediate design problems are solved, so new aspects of the product and its manufacture are discovered. To achieve a suitable level of power for a new vehicle, for example, a larger engine than had been initially envisaged may need to be included. This immediately places greater constrains on the size and layout of other components, so detailed design criteria are modified.

This process of refining criteria also arises when tasks are examined. As aspects of the task are uncovered, we realize increasingly what needs to be valued in terms of performance. For example, a task analysis might commence with the aim of improving human performance to gain greater productivity. Notions of safety may be uppermost, but only when task detail is understood are the implications of safety properly appreciated.

Just as a task has a purpose, so too does the task analyst's intervention in doing task analysis. The analyst might be involved in training, or developing a better control panel, or determining how people can work together most effectively, or several of these things. Task analysis should not be done for the sake of it; knowing why we are carrying out the analysis affects how the analysis progresses.

Plans are crucial to HTA. A plan only makes sense in conjunction with the subgoals it is governing. Thus, to refer back to our example of the toaster, we can use a plan which states that first we must ensure power to the toaster, then we must insert the bread, then we push down the lever, then when the toast pops up, we remove the toast. If the toast is satisfactory we can terminate the toaster operation. If the toast is unsatisfactory we can adjust the toaster then repeat part of the previous activity.

Carrying out HTA on any task entails similar processes to those described for using the toaster. HTA works towards understanding what is necessary to achieve the stated goal. The analyst keeps in mind the performance criteria involved. As the analysis proceeds, the criteria for performance and why these different things are important start to make more sense.

Appendix E: Participant Handout for Experimental Group 1

Procedural Steps in conducting a Hierarchical Task Analysis

1. *Define the purpose of the analysis*

Examples of different purposes of HTA would include task design, interface design, and training design.

2. *Define the boundaries of the task description*

In other words perform the analysis appropriate to the intended purpose to which it is to be put.

3. *Try to access a variety of sources of information about the task to be analyzed*

Gather as much information as possible about the task that you are attempting to analyze.

4. *Describe the task goals*

State the initial goals of the task

5. *Redescribe the task goals into subgoals*

As goals are broken down and new operations emerge, subgoals for each of the operations need to be identified.

6. *Link goals to subgoals and describe the conditions under which subgoals are triggered*

Plans are the control structures that enable the analyst to capture the conditions which trigger the subgoals under any super-ordinate goal. They are read from the top of the hierarchy down to the subgoals that are triggered and back up the hierarchy again as the exit conditions are met. Exit conditions are important to ensure an end to the analysis.

7. *Stop re-describing the subgoals when you judge the analysis is fit for purpose*

The level of description is likely to be highly dependent upon the purpose of the analysis, so it is conceivable that a stopping rule could be generated at that point in the analysis.

Appendix F: Participant Handout for Experimental Group 2

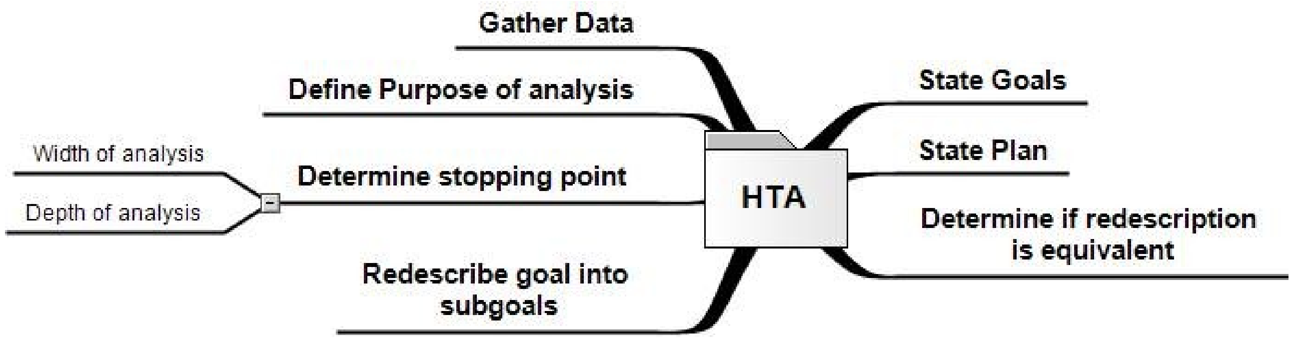
Decision-Action Diagram of Hierarchical Task Analysis

State Overall Goal
State Subordinate Operations
State Plan
Check adequacy of redescription
Is redescription alright?
No
Revise redescription
Yes
Consider first/next suboperation
Is further redescription warranted?
Select next operation
Yes
Terminate redescription of this operation
No

Yes
Do any unexamined operations remain?
No
Task Analysis Complete

Appendix G: Participant Handout for Experimental Group 3

Concept Map of Hierarchical Task Analysis



Appendix H: Task 1

Task 1: Making a Piece of Toast

Master Task Analysis | **0: Making a piece of Toast** | 11 November 2009

<u>Minimum goals</u>

1. **Determine recipe**
2. **Follow recipe**
3. **Get materials**
   3.1. Gather cooking apparatus
   3.2. Gather pots and pans
   3.3. Gather utensils
   3.4. Gather ingredients
4. **Prepare ingredients**
   4.1. Get ingredients out
   4.2. Warm or cool ingredients
   4.3. Slice or cut ingredients
   4.4. Measure ingredients
5. **Mix ingredients**
   5.1. Combine ingredients
   5.2. Season to taste
      5.2.1. Determine need for seasoning
      5.2.2. Select seasoning (e.g., salt, sugar)
      5.2.3. Find seasoning
      5.2.4. Add (apply) seasoning
6. **Prepare technology**
   6.1. Determine method of preparation
   (e.g., cold vs. warm such as stove, oven, microwave)
   6.2. Power-up technology
      6.2.1. provide power
      6.2.2. preheat
7. **Prepare food** (e.g., cook, brew, steam)
   7.1. Adjust temperature of cooking technology
   7.2. Input ingredients to medium
   7.3. Monitor time
   7.4. Check for doneness
   7.5. Remove ingredients from medium
8. **Plate dish**
   8.1. Add dish
   8.2. Add toppings (e.g., pickles, tomatoes, sauces)
   8.3. Arrange garnishment

<u>Additional goals</u>

9. **Wrap-up**
   9.1. Turn-off equipment
   9.2. Store away
   9.3. Clean (wipe, scrub, rinse)
10. **Serve**
   10.1. Decide on serving details
   10.2. Get serving materials
      10.2.1. Gather dish
      10.2.2. Gather utensils
      10.2.3. Gather plates
      10.2.4. Gather garnishment
   10.3. Hand over dish

Appendix I: Task 2

Task 2 (T2): Making a Cup of Coffee

Master Task Analysis | **0: Making a cup of coffee** | 11 November 2009

Minimum goals

1. **Determine recipe**
2. **Follow recipe**
3. **Get materials**
   3.1. Gather cooking apparatus
   3.2. Gather pots and pans
   3.3. Gather utensils
   3.4. Gather ingredients
4. **Prepare ingredients**
   4.1. Get ingredients out
   4.2. Warm or cool ingredients
   4.3. Slice or cut ingredients
   4.4. Measure ingredients
5. **Mix ingredients**
   5.1. Combine ingredients
   5.2. Season to taste
      5.2.1. Determine need for seasoning
      5.2.2. Select seasoning (e.g., salt, sugar)
      5.2.3. Find seasoning
      5.2.4. Add (apply) seasoning
6. **Prepare technology**
   6.1. Determine method of preparation
   (e.g., cold vs. warm such as stove, oven, microwave)
   6.2. Power-up technology
      6.2.1. provide power
      6.2.2. preheat
7. **Prepare food** (e.g., cook, brew, steam)
   7.1. Adjust temperature of cooking technology
   7.2. Input ingredients to medium
   7.3. Monitor time
   7.4. Check for doneness
   7.5. Remove ingredients from medium
8. **Pour dish**
   8.1. Add dish
   8.2. Add toppings (e.g., sugar, milk)
   8.3. Arrange garnishment

Additional goals

9. **Wrap-up**
   9.1. Turn-off equipment
   9.2. Store away
   9.3. Clean (wipe, scrub, rinse)
10. **Serve**
   10.1. Decide on serving details
   10.2. Get serving materials
      10.2.1. Gather dish
      10.2.2. Gather utensils
      10.2.3. Gather plates
      10.2.4. Gather garnishment
   10.3. Hand over dish

Appendix J: Task 3

Task 3 (T3): Making a Phone Call

Master Task Analysis **0: Making a phone call** 11 November 2009

Minimum goals

1. **Determine receiver information**
   1.1. choose receiver
   1.2. find phone number
2. **Obtain phone**
   2.1. recall what phones are available (e.g., cell phone vs. land line)
   2.2. choose phone (e.g., cell phone)
   2.3. locate phone
3. **Connect**
   3.1. Establish communication with phone
   3.2. Communicate receiver information (dial number)
   3.3. Initiate connection
   3.4. Verify connection

Additional goals

4. **Communicate**
   4.1. Talk
   4.2. Listen
5. **End call**
   5.1.1. Determine end in the conversation
   5.1.2. Determine method of disconnecting (close phone, push button)
   5.1.3. Disconnect (Activate disconnection mechanism)
   5.1.4. Disengage from phone

Appendix K: Task 4

Task 4 (T4): Painting a Door

Master Task Analysis **0: Painting a door** 11 November 2009

Minimum goals

1. **Gather materials**
   1.1. Choose color
   1.2. Choose paint
      1.2.1. shine
      1.2.2. quality
   1.3. Obtain paint
   1.4. Obtain supplies (e.g., tape, rollers, spray, cloth)
2. **Place door in accessible position**
   2.1. Remove hinges
   2.2. Transport door
3. **Protect areas from paint**
   3.1. determine which parts to remove
   3.2. determine which parts to cover
   3.3. remove door parts
   3.4. cover area/floor/ground
   3.5. cover door parts
4. **Prepare door for paint**
   4.1. Remove old paint
      4.1.1. sand door
      4.1.2. treat with chemicals
   4.2. Clean surface
5. **Apply paint coat**
   5.1. Determine number of coats
   5.2. Select materials
   5.3. Prepare materials
   5.4. Apply coat
   5.5. Let dry
      5.5.1. Monitor time
      5.5.2. Check dryness
   5.6. Remove excess paint
   5.7. Verify coat quality

Additional goals

6. **Wrap-up**
   6.1. Uncover areas
      6.1.1. remove area/floor/ground cover
      6.1.2. remove door cover parts
   6.2. Reposition door
      6.2.1. reapply parts
      6.2.2. reapply hinges
   6.3. Clean-up
      6.3.1. Differentiate between recycle and reuse and throwaway
      6.3.2. Recycle materials
      6.3.3. Prepare material for reuse
      6.3.4. Throw away materials

Appendix L: Task 5

Task 5: Preparing the Dish Vetkoek (a South African main course):

Master Task Analysis **0: Making Vetkoek (a South African main dish)** 11 November 2009

Minimum goals

1. Determine recipe
2. Follow recipe
3. Get materials
- 3.1. Gather cooking apparatus
- 3.2. Gather pots and pans
- 3.3. Gather utensils
- 3.4. Gather ingredients

***4.* Prepare ingredients**
- 4.1. Get ingredients out
- 4.2. Warm or cool ingredients
- 4.3. Slice or cut ingredients
- 4.4. Measure ingredients

5. Mix ingredients
- 5.1. Combine ingredients
- 5.2. Season to taste
  - 5.2.1. Determine need for seasoning
  - 5.2.2. Select seasoning (e.g., salt, sugar)
  - 5.2.3. Find seasoning
  - 5.2.4. Add (apply) seasoning

6. Prepare technology
- 6.1. Determine method of preparation (e.g., cold vs. warm such as stove, oven, microwave)
- 6.2. Power-up technology
  - 6.2.1. provide power
  - 6.2.2. preheat

7. Prepare food (e.g., cook, brew, steam)
- 7.1. Adjust temperature of cooking technology
- 7.2. Input ingredients to medium
- 7.3. Monitor time
- 7.4. Check for doneness
- 7.5. Remove ingredients from medium

8. Plate dish
- 8.1. Add dish
- 8.2. Add toppings (e.g., pickles, tomatoes, sauces)
- 8.3. Arrange garnishment

Additional goals

9. Wrap-up
- 9.1. Turn-off equipment
- 9.2. Store away
- 9.3. Clean (wipe, scrub, rinse)

10. Serve
- 10.1. Decide on serving details
- 10.2. Get serving materials
  - 10.2.1. Gather dish
  - 10.2.2. Gather utensils
  - 10.2.3. Gather plates
  - 10.2.4. Gather garnishment
- 10.3. Hand over dish

Appendix M: Procedural Knowledge Coding Booklet

<u>Overview of the codes</u>

(1) State high-level goal
    a. Mentioned
    b. Not mentioned

(2) State plan (order/sequence) <u>(2 codes)</u>
    a. The word ‘plan’ mentioned
    b. The word ‘plan’ not mentioned

    c. Style (bulleted list, numbered list, text, diagram etc)

(3) Hierarchical approach
    a. Breadth (at the first level) – (# of items, sentences etc.)
    b. Depth (# of items sentences etc. maximum)

(4) State satisfaction criteria
    a. Mentioned
    b. Not mentioned

(5) Generalizability (**Extra**)
    a. General
    b. Specific

(6) State subgoals <u>(2 codes)</u>
    a. The word ‘subgoal’ mentioned
    b. The word ‘subgoal’ not mentioned

    c. Code whether subgoal is on high-level in master TA
        i. Minimum goal
        ii. Additional goal
        iii. Goal not in master TA

(7) If-then Statements (**Extra**)
    a. Count the number of statements

(8) Decide-Statements (**Extra**)
    a. Count the number of statments

Detailed coding scheme

(1) State high-level goal:

- Stating a goal is defined as identifying the main high level task goal that is to be achieved.

Code	***Explanation***	***Example***
Goal mentioned	The higher-level goal is mentioned as a goal	Goal: Make a phone call "Decide what needs to be done to paint a door." "Decide you need to make a phone call"
Goal not mentioned	The higher-level goal is not identified/mentioned in any form	1. First you should make sure the phone is connected and has a dial tone by picking up the receiver and listening 2. Next, while hearing the dial ton, punch in the correct digits of the phone number you would like to reach on the number pad

(2) Stating a Plan (have plan):

- The plan includes the order of the elements taken to reach the goal and/or subgoal. The task analyses will be coded on whether or not order has been expressed.

- In a first go-through just code whether participants used the label 'plan'.

Code	***Explanation***	***Example***
Plan mentioned	The word "plan" was mentioned	-Plan: Acquire the correct amount of water in the teapot.
Plan not mentioned	The word "plan" was not mentioned	n/a

- Then code the surface feature of the task analyses (e.g., bulleted list, numbered list, paragraph)

Code	***Explanation***
Style	- Bulleted list - Numbered list - Paragraph/Text - Flow-chart - List other (e.g., one idea per row without bullet or number) - Other

Note:

If text → use keywords such as next, if-then etc.
If more than one style applies, list all by adding a '+' sign

(3) Hierarchical approach:

The hierarchical approach is designated by the level (depth) of the analysis and the breadth of the analysis. Each task analysis product will be coded on both dimensions.

Code	***Explanation***	***Example***
Breadth @ level 1	- The high-level goal is designated as level 0. Code the number of elements @ level 1, so not including the high-level goal	0. Make coffee 1. Get coffee 2. Get machine 3. Fill in coffee…
Depth (maximum)	- Number of elements deep at most, with the high-level goal being level 0. List of steps has a depth of 1, irrespective of whether they mention the high-level goal.	

Notes:

- For bullets/lists:
  - → count the number of bullets for breadth, and the number of sub-levels for depth.
- For flowchart:
  - → count the number of bullets for breadth, and the number of sub-levels for depth.
  - → A → B → C means Depth of 3, Breadth of 1
  - → A → B double-arrow to C /D means Depth of 2, Breadth of 2, as a branching indicates an increase in depth rather than breadth. If two branches combine to one again, this means an increase in breadth again.
- For paragraphs/text
  - → Breadth is the number of paragraphs
  - → Depth is the number of sentences within a paragraph, separated by a period. So listing within a sentence is considered sublevels on the same level

(4) Criteria / Constraints against which judged satisfactory:

- Checking for satisfactory is one of the final steps for conducting a task analysis. When you perform a task, it must be judged as whether or not it is performed adequately. The task analyses will be coded on whether satisfaction criteria were mentioned, either at the onset or the end of the task analysis.

Code	***Explanation***	***Example***
Criteria mentioned and specified	Mention checking satisfaction as well as the steps taken to correct if not satisfactory (if-then (conditional) statement)	Be able to drink: blow on tea *until cooled enough to drink. Add more sweetener if needed.* -Subgoal: Ensure the tea is made correctly -Plan: move the teabag around and press on it to ensure that the tea has come out of the bag. Taste the tea to see if it is to your liking, if it is, then a cup of tea has been successfully made OR Goal: To make a cup of tea to taste (milk and sugar)
No criteria/constraints mentioned	Does not mention anywhere a criterion for satisfaction or checking for satisfaction	Plan: once the numbers are displayed on the phone press the talk button and the phone up to your ear and wait for the phone to start ringing.

(5) Generalizability (Extra)

- Generalizability refers to whether the task analysis can be applied to various implementations. A task analysis will be evaluated as to whether it mentions a specific ingredient, equipment. If none is mentioned, then the task analysis receives the code of ‘general’. If specific technology is mentioned, then each instance is counted, and the task analysis will be assigned the total number of instances mentioned and coded as ‘specific-number’.

Code	***Explanation***	***Example***
General	Does not specifically mention a technology, ingredient, or location	Goal: To make a cup of tea. - Subgoal: Prepare water to make tea - Plan: Acquire the correct amount of water
Specific	Mentions a specific technology or ingredient. -	Goals: Talk to correct person over phone. Subgoals: Find #, dial into phone 1. Decide what person to talk to 2. Acquire # of person: Use phonebook, contacts in phone/computer, anywho.com, ask a friend

<table>
<tr><th></th><th>Different ingredients</th><th>Different equipment</th><th>Different location</th></tr>
<tr><td>Coffee</td><td>instant vs. ground coffee</td><td>microwave vs. stove</td><td rowspan="5">• at home
• at another person’s kitchen/place
• restaurant (ordered)
• Starbucks (bought)</td></tr>
<tr><td>Toast</td><td>cut slices vs. whole bread</td><td>toaster vs. toaster oven vs. frying pan</td></tr>
<tr><td>Paint</td><td>aerosol can vs. liquid paint</td><td>sprayer vs. paintbrush vs. roller</td></tr>
<tr><td>Phone</td><td>speed dial vs.
phone contact list vs.
memory vs. written</td><td>cell phone vs.
pay phone vs.
landline</td></tr>
<tr><td>Vetkoek</td><td>fresh vs. frozen</td><td></td></tr>
</table>

(6) Stating Subgoals (redescribe goals into subgoals):

- Stating subgoals or redescribing goals into subgoals is an element of HTA. With this criterion we determine whether the subgoal participants stated is found somewhere in our master Task Analysis. By definition/assumption, the master Task Analysis is a nested hierarchy of subgoals Also code whether participants used the label 'subgoal' correctly.

Code	***Explanation***	***Example***
Label mentioned	The word "subgoal" was used to indicate a subordinate element.	Subgoal: **ADD**. Subgoal: **ADD**
Label not mentioned	The word "subgoal" was not used in the task analysis	n/a

Also code on which specific subgoals were addressed.

Code	***Explanation***	***Example***
Subgoal found in master TA – minimum goals	Content of element is a minimum (necessary) goal in the master TA	Heat water
Subgoal found in master TA – additional goal	Content of element is a minimum (necessary) goal in the master TA.	Clean up
Subgoal not in master TA	Content of element is not found anywhere in the master TA	

Appendix N: Participant Assignment Chart with Counterbalancing and Experimental Training Condition

Counterbalance group	Task	Procedural Steps	Decision-Action Diagram	Concept Map
C1	T2, T3, T4	Participant 2	Participant 11	Participant 9
C2	T2, T4, T3	Participant 7	Participant 17	Participant 3
C3	T3, T2, T4	Participant 12	Participant 1	Participant 6
C4	T3, T4, T2	Participant 4	Participant 16	Participant 14
C5	T4, T2, T3	Participant 15	Participant 5	Participant 18
C6	T4, T3, T2	Participant 8	Participant 13	Participant 10

Appendix O: Demographics Questionnaire

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding the

Demographics Questionnaire

Gender: Male ☐1 **Female** ☐2 **Date of Birth: __ __ / __ __ / __ __** **Age: _______**

1. **What is your highest level of education?**

☐1 No formal education
☐2 Less than high school graduate
☐3 High school graduate/GED
☐4 Vocational training
☐5 Some college/Associate's degree
☐6 Bachelor's degree (BA, BS)
☐7 Master's degree (or other post-graduate training)
☐8 Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)

2. **Current marital status (check one)**

☐1 Single
☐2 Married
☐3 Separated
☐4 Divorced
☐5 Widowed
☐6 Other (please specify) _________________

3. **Do you consider yourself Hispanic or Latino?**

☐1 Yes
☐2 No

3 a. If "Yes", would you describe yourself:

☐1 Cuban
☐2 Mexican
☐3 Puerto Rican

☐4 Other (please specify) ________________

4. **How would you describe your primary racial group?**

☐1 No Primary Group
☐2 White Caucasian
☐3 Black/African American
☐4 Asian
☐5 American Indian/Alaska Native
☐6 Native Hawaiian/Pacific Islander
☐7 Multi-racial
☐8 Other (please specify) ______________________

5. **In which type of housing do you live?**

☐1 Residence hall/College dormitory
☐2 House/Apartment/Condominium
☐3 Senior housing (independent)
☐4 Assisted living
☐5 Nursing home
☐6 Relative's home
☐7 Other (please specify) ________________

6. **Which category best describes your yearly household income. Do not give the dollar amount, just check the category:**

☐1 Less than $5,000
☐2 $5,000 - $9,999
☐3 $10,000 - $14,999
☐4 $15,000 - $19,999
☐5 $20,000 - $29,999
☐6 $30,000 - $39,999
☐7 $40,000 - $49,999
☐8 $50,000 - $59,999
☐9 $60,000 - $69,999

- ☐$_{10}$ \$70,000 - \$99,999
- ☐$_{11}$ \$100,000 or more
- ☐$_{12}$ Do not know for certain
- ☐$_{13}$ Do not wish to answer

7. **Is English your primary language?**

- ☐$_1$ Yes
- ☐$_2$ No

7 a. If "No", What is your primary language? ______________________

8. What is your primary mode of transportation? (Check <u>one</u>)

- ☐$_1$ Drive my own vehicle
- ☐$_2$ A friend or family member takes me to places I need to go
- ☐$_3$ Transportation service provided by where I live
- ☐$_4$ Use public transportation (e.g., bus, taxi, subway, van services)

<u>Occupational Status</u>

9. What is your primary occupational status? (Check <u>one</u>)

- ☐$_1$ Work full-time
- ☐$_2$ Work part-time
- ☐$_3$ Student
- ☐$_4$ Homemaker
- ☐$_5$ Retired
- ☐$_6$ Volunteer worker
- ☐$_7$ Seeking employment, laid off, etc.
- ☐$_8$ Other (please specify) ____

10. Do you currently work for pay?

☐1 Yes, Full-time
☐2 Yes, Part-time
☐3 No

10 a. If "Yes", what is your primary occupation?

____

<u>Additional educational information:</u>

11. **What year are you in school?**

☐1 Freshman
☐2 Sophomore
☐3 Junior
☐4 Senior
☐5 other

11 a. If "other", please describe ______________________________

12. **What is your major? ______________________________**
13.
14.
15. **Have you heard about or conducted a task analysis before this study?**
16.
17. ☐1 Yes
18. ☐2 No
19.
20.
21. **13 a. If "Yes", please describe when and where**

22. ____

____

___

23.
24.
25.
26.
27. **Have you ever taken a course that discussed task analysis?**
28.
29. ☐1 Yes
30. ☐2 No
31.
32.
33. **14 a. If "Yes", please list the name of the course and when you took it**
34. ____

____

___

35.

36.
37.
38.
39.

40.

41. Appendix P: Exit Questionnaire

42. **Exit Questionnaire**

1. **Please list and briefly describe five main features of Hierarchical Task Analysis**

43.

44. a)____

____

45.____

___

46. b)____

47.____

___ c)________________________________

____

48.____

___

49. d)____

50.____

___ e)________________________________

51.____

___

52.

2. **What aspects of the analysis were easy to perform? Please explain.**

53.

54. ____

____

____

_____

55. ____

___

56.

57.

58.

59.

3. **What aspects of the analyses were difficult to perform? Please explain.**

60. ____

____

____

_____

Making a piece of toast

A. **How easy or difficult it was to perform the task analysis on making a piece of toast?**

☐1 ☐2 ☐3 ☐4 ☐5

very easy very difficult

B. **How confident are you in your task analysis of making a piece of toast?**

☐1 ☐2 ☐3 ☐4 ☐5

not very confident very confident

C. **How familiar are you with making a piece of toast?**

☐1 ☐2 ☐3 ☐4 ☐5

not very familiar very familiar

D. **How frequently do you make a piece of toast?**

☐1 ☐2 ☐3 ☐4 ☐5

never yearly or less often monthly weekly daily

E. **How did you go about decomposing the task?**

____

____

____

_____

84. **<u>Making a cup of coffee</u>**

85.

A. **How easy or difficult it was to perform the task analysis on making a cup of coffee?**
86.
87. ☐1 ☐2 ☐3 ☐4 ☐5
88. very easy very difficult
89.
90.
B. **How confident are you in your task analysis of making a cup of coffee?**
91.
92. ☐1 ☐2 ☐3 ☐4 ☐5
93. not very confident very confident
94.
95.
C. **How familiar are you with making a cup of coffee?**
96.
97. ☐1 ☐2 ☐3 ☐4 ☐5
98. not very familiar very familiar
99.
100.
D. **How frequently do you make a cup of coffee?**
101.
102. ☐1 ☐2 ☐3 ☐4 ☐5
103. never yearly or monthly weekly daily
104. less often

105.
E. **How did you go about decomposing the task?**
106. ____

____

____

____

<u>Making a phone call</u>

A. **How easy or difficult it was to perform the task analysis on making a phone call?**

☐1	☐2	☐3	☐4	☐5
very easy				very difficult

B. **How confident are you in your task analysis of making a phone call?**

☐1	☐2	☐3	☐4	☐5
not very confident				very confident

C. **How familiar are you with making a phone call?**

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

D. **How frequently do you make a phone call?**

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

E. **How did you go about decomposing the task?**

____

____

____

____

Painting a door

A. **How easy or difficult it was to perform the task analysis on painting a door?**

☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
very easy				very difficult

B. **How confident are you in your task analysis of painting a door?**

☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
not very confident				very confident

C. **How familiar are you with painting a door?**

☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
not very familiar				very familiar

D. **How frequently do you painting a door?**

☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
never	yearly or less often	monthly	weekly	daily

E. **How did you go about decomposing the task?**

____

____

____

____

153. **<u>Preparing the dish Vetkoek</u>**

154.

A. **How easy or difficult it was to perform the task analysis on preparing Vetkoek?**
155.
156. ☐1 ☐2 ☐3 ☐4 ☐5
157. very easy very difficult
158.
159.
B. **How confident are you in your task analysis of preparing Vetkoek?**
160.
161. ☐1 ☐2 ☐3 ☐4 ☐5
162. not very confident very confident
163.
164.
C. **How familiar are you with preparing making Vetkoek?**
165.
166. ☐1 ☐2 ☐3 ☐4 ☐5
167. not very familiar very familiar
168.
169.
D. **How frequently do you preparing Vetkoek?**
170.
171. ☐1 ☐2 ☐3 ☐4 ☐5
172. never yearly or monthly weekly daily
173. less often

174.
E. **How did you go about decomposing the task?**
175. ____

____

____

____

176. **<u>Thinking back to all the task analysis you performed</u>**

177.

4. **How did you identify the goals and subgoals?**

178.

179. ____

____

____

____

180.

5. **How did you show the order of the task elements?**

181.

182. ____

____

____

____

183.

6. **How did you decide on the <u>breadth</u> of the analysis, that is, where to start and where to end the task?**

184.

185. ____

____

____

____

186.

7. **How did you decide on the <u>depth</u> of the analysis, that is, to which level to analyze to?**

187.

188. ____

____

189.

8. **What influenced your decision about which elements to analyze further?**

190.

191.

192.

9. **Did the training help in your ability to perform the task?**

193.

194. ☐1 ☐2 ☐3 ☐4 ☐5

195. not very much very much

196.

197. **Please explain**

198.

199.

200.

10. **Do you feel that performing a HTA of a system would be an effective way to learn a task?**

201.

202. ☐1 ☐2 ☐3 ☐4 ☐5

203. not very much very much

204.

205. **Please explain**

206.

207.

208.

11. **Any additional comments?**

209.

210. ____

____

____

211. Appendix Q: Debriefing

212. Training Novices on Hierarchical Task Analysis

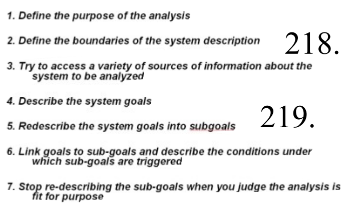
213.

214. <u>Debriefing Information</u>

215.

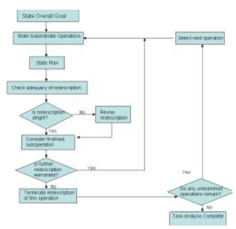
216. Thank you very much for participating in this study. This study was conducted to help us understand what instructional method is most effective when training novices on Hierarchical Task Analysis (HTA). We assigned you to one of three instructional conditions that emphasize different aspects of HTA: procedural instructions, decision-action diagram, or concept map. The following are examples of the three conditions:

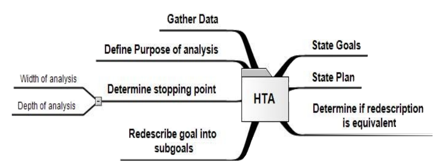
217. Procedural Steps | Decision-Action Diagram | Concept Map



218.

219.





220.

221. We are interested to see how the different emphases affect the resulting task analyses.

222. More generally, this study will provide us with information regarding how the training of HTA affects acquisition of skill in the early stages. In addition, it will allow us to gauge the complexity and amount of information learned from the training, through the performance of conducting the analyses. The purpose of the study is also to explore the nature of errors that occur as well as how familiarity with the tasks to be analyzed will affect the resulting analysis.

223. If you are interested, we will share a summary of the results with you by mailing you a newsletter at your request. Because each individual's data and test scores are completely confidential, there will be no way for us to mail your individual results. Your data will provide valuable insight into training of HTA. If you have any questions, please feel free to contact us.

224.

Thank you for your time and cooperation.

225.

Human Factors and Aging Lab

226.

Georgia Institute of Technology (404) 894-8344

227.

Dr. Dan Fisk and Dr. Wendy Rogers

228.
229.
230.

231.

232. Appendix R: Distribution of Subgoals: Door

233.

234. Door		235. Condition			236.
237.	238. Proc.	239. D/A	240. Concept	241. *Sum*	242. %
243. 1. Determine materials	244. 0	245. 0	246. 0	247. *0*	248. 0
249. 1.x	250. 2	251. 7	252. 11	253. *20*	254. **11.2**
255. 2. Get materials	256. 0	257. 0	258. 0	259. *0*	260. 0.0
261. 2.x	262. 15	263. 12	264. 9	265. *36*	266. **20.1**
267. 3. Place door in position	268. 0	269. 0	270. 0	271. *0*	272. 0.0
273. 3.x	274. 0	275. 0	276. 0	277. *0*	278. 0.0
279. 4. Protect area	280. 1	281. 0	282. 0	283. *1*	284. 0.6
285. 4.x	286. 2	287. 4	288. 7	289. *13*	290. 7.3
291. 5. Prepare door for paint	292. 1	293. 0	294. 0	295. *1*	296. 0.6
297. 5.x	298. 0	299. 1	300. 1	301. *2*	302. 1.1
303. 6. Apply paint coat	304. 1	305. 1	306. 2	307. *4*	308. 2.2
309. 6.x	310. 29	311. 25	312. 28	313. *82*	314. **45.8**
315. 7. Wrap up	316. 0	317. 0	318. 0	319. *0*	320. 0.0
321. 7.x	322. 4	323. 3	324. 7	325. *14*	326. 7.8
327. 8. Reposition door	328. 0	329. 0	330. 0	331. *0*	332. 0.0
333. 8.x	334. 0	335. 0	336. 0	337. *0*	338. 0.0
339. other goals	340. 0	341. 0	342. 6	343. *6*	344. 3.4
345. Sum	346. 55	347. 53	348. 71	349. 179	350.

351.

352.

353. Appendix S: Distribution of Subgoals: Phone

354.

355.

356. Phone		357. Condition			358.	359.
360.	361. Proc.	362. D/A	363. Concept	364. *Sum*	365. %	366.
367. 1. Determine receiver	368. 0	369. 0	370. 0	371. *0*	372. 0	373.
374. 1x	375. 3	376. 6	377. 4	378. *13*	379. 9.9	380.
381. 2. Obtain phone	382. 0	383. 0	384. 1	385. *1*	386. 0.8	387.
388. 2.x	389. 8	390. 7	391. 12	392. *27*	393. 20.6	394.
395. 3. Connect	396. 1	397. 0	398. 0	399. *1*	400. 0.8	401.
402. 3.x	403. 18	404. 17	405. 20	406. *55*	407. 42.0	408.
409. 4. Communicate	410. 1	411. 0	412. 1	413. *2*	414. 1.5	415.
416. 4.x	417. 4	418. 3	419. 5	420. *12*	421. 9.2	422.
423. 5. End call	424. 0	425. 0	426. 0	427. *0*	428. 0.0	429.
430. 5.x	431. 5	432. 5	433. 8	434. *18*	435. 13.7	436.
437. other	438. 1	439. 0	440. 1	441. *2*	442. 1.5	443.
444. Sum	445. 41	446. 38	447. 52	448. 131	449. 100%	450.

451.